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KIM KEUNG WONG

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled AN INVESTIGATION OF HOLLAND'S PERSONALITY TYPES AND ENGINEERING SPECIALTIES submitted by KIM KEUNG WONG in partial fulfillment of the requirements for the degree of Master of Education in Counseling Psychology.

This thesis is dedicated to my parents with love.

敬獻給親愛的父母親

***** ***** *****

The fear of the Lord is the beginning of wisdom,
and knowledge of the Holy One is understanding.

Proverbs 9:10

Of making many books there is no end,
and much study wearies the body.

Ecclesiates 12:12

ABSTRACT

The purpose of this study was threefold: (1) to investigate whether there is any difference in personality patterns as operationalized by Holland's Vocational Preference Inventory (V.P.I.) (Holland, 1973) scores of engineering students and engineers in different specialties, (2) to examine whether there is any difference in personality patterns of the engineering students at various stages of their preparation and, (3) to study whether there is any age-related personality change in engineers of different age groups and any difference in personality patterns of engineers who have considered change of occupation and those who have not.

The sample consisted of 128 male, second year or fourth year Chemical, Civil, and Mechanical engineering students at University of Alberta, and 74 male Chemical, Civil, and Mechanical engineers in Edmonton, Alberta. Each was sent a general instruction, a general questionnaire and the Vocational Preference Inventory with a self-addressed stamped envelope. The raw scores of the V.P.I. of the subjects were treated statistically to determine the presence of significant differences.

The findings tended to support Holland's theory of vocational choice (1973) proposing that individuals tend to choose actual occupational environments consistent with their personality types, and on the aspect of career change postulating that "people leave because of excessive person-environment incongruent, or because of an opportunity to increase their congruity" (Holland & Gottfredson,

1976, p.21). The results also supported the postulate that the student body of a particular program would have a personality pattern more consistent with the members of the intended Occupational Environment as the length of time spent in the program increases. Mechanical engineering students and engineers were found significantly different from Chemical and Civil engineering students and engineers in personality patterns, lending general support to the proposition that "engineers should not be lumped together into a single category" (Dunnette et al., 1964, p.492).

Finally, some implications for further research and counseling were discussed.

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INTRODUCTION

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John Holland's theory of vocational choice attempts to relate personality characteristics to vocational choice. He states that "the choice of an occupation is an expressive act which reflects the person's motivation, knowledge, personality, and ability" (Holland, 1973, p.7). His theory proposes that individuals tend to choose actual occupational environments consistent with their personality types. In terms of career change, Holland has made the prediction even more explicit in a recent clarification of his theory: "In theoretical terms, people leave because of excessive person-environment incongruent, or because of an opportunity to increase their congruity" (Holland & Gottfredson, 1976, p.21). Studies using his theoretical framework have shown relationships between particular groups of personality traits and particular groups of preferred vocations (Holland, 1962, 1968; Osipow, Ashby & Wall, 1967; Bailey, 1971; Folsom, 1972; Hanselman, 1972; Holland, 1973; Andrews, 1975; Meadows, 1975; Fishburne & Walsh, 1976; Walsh, Horton & Gaffey, 1977; Salomone & Slaney, 1978; Spokane & Walsh, 1978). Therefore, it would seem reasonable to assume that students preparing for a particular occupation would have personalities consistent with those of the members of the intended occupation and that the personalities of those who have considered change of occupation would be different from those who have not.

Moreover, studies of occupational choice among college students

tend to treat engineering as a single entity: (three notable exceptions are Neal & King (1969), Molnar & Delauretis (1973), Izraeli, Krausz & Garber (1979)). They fail to distinguish among engineering specialties, but rather compare the interests of students attracted to engineering as a whole with those of students in other fields. Furthermore, there are few studies on the difference in personalities for engineers in different job duties such as Basic Research, Applied Research and Development, Production and Process and, Sales and Technical Service.

The Purpose

The purpose of the present study is to answer the following questions:-

1. Are there any differences in personality patterns (according to Holland's Vocational Preference Inventory (V.P.I.) Classification (Holland, 1973)) between students in engineering program (Chemical, Civil, and Mechanical) and the respective engineers in the field?
2. Are there any differences in personality patterns (according to Holland's V.P.I. Classification) of the engineering students at various stages of their preparation?
3. Are there any differences in personality patterns (according to Holland's V.P.I. Classification) among engineers in different age groups?
4. Are there any differences in personality patterns (according to Holland's V.P.I. Classification) between engineers who have considered change of occupation and those who have not?
5. Are there any differences in personality patterns (according

to Holland's V.P.I. Classification) among engineering students in different specialties, namely, Chemical, Civil, and Mechanical Engineering?

6. Are there any differences in personality patterns (according to Holland's V.P.I. Classification) among engineers in different specialties, namely, Chemical, Civil, and Mechanical Engineering?
7. Are there any differences in personality patterns (according to Holland's V.P.I. Classification) among engineers in different job duties, namely, Basic Research, Applied Research and Development, Production and Process and, Sales and Technical Service?

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter is presented in four parts: the first presenting Holland's theory of vocational choice, the second dealing with empirical studies on the relationship of personality and vocational choice, the third with research studies on engineering students and engineers, and the fourth part dealing with personality change over time.

Holland's Theory of Vocational Choice

The theory consists of several simple ideas and their more complex elaborations as presented in his book "Making Vocational Choices" (Holland, 1973). First, people may be characterized by their resemblance to each of six personality types: Realistic, Intellectual, Artistic, Social, Enterprising, and Conventional. The more closely a person resembles a particular type, the more likely he/she is to exhibit the personal traits and behaviors associated with that type. Second, the environments in which people live can be characterized by their resemblance to six model environments: Realistic, Intellectual, Artistic, Social, Enterprising, and Conventional. Finally, the pairing of persons and environments leads to outcomes that can be predicted and understood from the knowledge of the personality types and the environmental models. These outcomes include vocational choice, vocational stability and achievement, personal competence, social behavior, and susceptibility to influence.

Four Assumptions The heart of the theory is constituted by four working assumptions. They indicate the nature of the personality

types and environmental models, how the types and models are determined, and how they interact to create the phenomena - vocational, educational, and social - that the theory is meant to explain.

1. In the western culture, most persons can be categorized as one of six types: Realistic, Intellectual, Artistic, Social, Enterprising, or Conventional. The description of each type is both a summary of what one knows about people in a given occupational group and a special way of comprehending this information: It is a theoretical or ideal type. A type is a model against which one can measure the real person. Each type is the product of a characteristic interaction between a variety of cultural and personal forces, including peers, parents, social class, culture, and the physical environment. Out of this experience, a person learns first to prefer some activities as opposed to others. Later, these activities become strong interests. Such interests lead to a special group of competencies. Finally, a person's interests and competencies create a particular personal disposition that leads him/her to think, perceive, and act in special ways. By comparing a person's attributes with those of each model type, one can determine which type he/she resembles most. That model becomes his/her personality type. Then one can also determine what other types he/she resembles. For example, a person resembles a Social type most, then an Enterprising type, then the other types in descending order. His/Her total resemblance to each of the six types forms a pattern of similarity and dissimilarity -

the person's personality pattern. To estimate a person's profile or personality pattern, one can use one of several methods: a person's scores on selected scales from interest and personality inventories, his/her choice of vocation or field of training, his/her work history of pre-employment aspirations, or combinations of these data. For example, certain scales of the Vocational Preference Inventory, the Strong Vocational Interest Blank, and the Self-Directed Search have been designed as estimates of the types.

2. There are six kinds of environments: Realistic, Intellectual, Artistic, Social, Enterprising, and Conventional. Each environment is dominated by a given type of personality, and each environment is typified by physical settings posing special problems and stresses. For example, Realistic environments are dominated by Realistic types of people - that is, the largest percentage of the population in the Realistic environment resembles the Realistic type. Because different types have different interests, competencies, and dispositions, they tend to surround themselves with special people and materials and to seek out problems that are congruent with their interests, competencies, and outlook on the world.
3. People search for environments that will let them exercise their skills and abilities, express their attitudes and values, and take on agreeable problems and roles. Realistic types seek Realistic environments, Social types seek Social

environments, and so forth.

4. A person's behavior is determined by an interaction between his/her personality and the characteristics of his/her environment. If one knows a person's personality pattern and the pattern of his/her environment, one can, in principle, use one's knowledge of personality types and environmental models to forecast some of the outcomes of such a pairing. Such outcomes include choice of vocation, job changes, vocational achievement, personal competence, and educational and social behavior.

Six Personality Types Holland's theory is built on the assumption that there are six different personal orientations to life. Each type is assumed to develop according to the following formula: To some degree, types produce types (Holland, 1973).

1. The Realistic Type: The Realistic type prefers "activities that entail the explicit, ordered, or systematic manipulation of objects, tools, machines, animals" and has:

> ..... an aversion to educational and therapeutic activities. These behavioral tendencies lead in turn to the acquisition of manual, mechanical, agricultural, electrical, and technical competencies and to a deficit in social and educational competencies. (Holland, 1973, p.14)

The Realistic person is apt to show himself/herself to be "asocial, conforming, masculine, practical, stable and uninsightful" (Holland, 1973, p.14). Realistic occupations include mechanical engineer, electrician, baker, mechanic, fisherman, barber, landscape architect and blacksmith etc..

2. The Intellectual Type: The Intellectual type prefers "activities that entail the observational, symbolic, systematic, and creative investigation of physical, biological, and cultural phenomena" and has "an aversion to persuasive, social, and repetitive activities." This leads to "acquisition of scientific and mathematical competencies and to a deficit in persuasive competencies" (Holland, 1973, p.14). The Intellectual is apt to show himself/herself to be "analytical, independent, intellectual, precise, unassuming and unpopular" (Holland, 1973, p.15). Intellectual occupations include: chemical engineer, civil engineer, electrical engineer, physicist, psychiatrist, geologist, computer operator, and airplane pilot etc..
3. The Artistic Type: The Artistic type prefers "ambiguous, free, unsystematized activities that entail the manipulation of physical, verbal, or human materials to create art forms or products" and has "an aversion to explicit, systematic, and ordered activities." This leads to "an acquisition of artistic competencies .... and a deficit in clerical or business system competencies" (Holland, 1973, p.15). The Artistic person is generally described as "complicated, disorderly, idealistic, imaginative, intuitive and unconforming" (Holland, 1973, p.16). Artistic occupations include: English teacher, musician, public relations man, fashion model, writer, furrier, and architect etc..
4. The Social Type: The Social type prefers "activities that entail the manipulation of others to inform, train, develop,

cure, or enlighten" and has "an aversion to explicit, ordered, systematic activities involving materials, tools, or machines." This leads to "an acquisition of human relations competencies .... and a deficit in manual and technical competencies" (Holland, 1973, p.16). The Social person is generally described as "co-operative, friendly, generous, insightful, persuasive, tactful and understanding" (Holland, 1973, p.16). Social occupations include: funeral director, historian, counselor, sociologist, social worker, school superintendent, politician, housewife, hair stylist, and clergyman.

5. The Enterprising Type: The Enterprising type has:

> .... a preference for activities that entail the manipulation of others to obtain organizational goals or economic gain; and an aversion to observational, symbolic, and systematic activities.

This leads to "an acquisition of leadership, interpersonal, and persuasive competencies, and to a deficit in scientific competencies" (Holland, 1973, pp. 16-17). The Enterprising person is apt to show himself/herself to be "acquisitive, ambitious, argumentative, domineering, flirtatious, self-confident, sociable and talkative" (Holland, 1973, p.17). Enterprising occupations include: banker, real estate salesman, contractor, lawyer, personnel manager, peddler, retail merchant, and travel guide.

6. The Conventional Type: The Conventional type prefers "activities that entail the explicit, ordered, systematic manipulation of data" and has "an aversion to ambiguous,

free, exploratory, or unsystematized activities." This leads to "an acquisition of clerical, computational, and business system competencies and to deficit in artistic competencies" (Holland, 1973, p.17). The Conventional person is apt to show himself/herself to be "conforming, conscientious, defensive, inflexible, orderly, practical, prudish and unimaginative" (Holland, 1973, p.18). Conventional occupations include: keypunch operator, file clerk, proofreader, business teacher, secretary, bookkeeper, and accountant etc..

Clearly, these six types are rarely presented in a pure form. Most people possess aspect of all six, but Holland suggests that each individual behaves in manner which reflects one or two of these styles much more strongly than the others, thus giving rise to the individual's peculiar orientation to life.

In addition to suggesting general behavioral styles that should result from living consistently with, or possibly two, of these life orientations, Holland's theory permits prediction about the kinds of careers, or college majors that people in the various categories should select. For example, engineers should primarily be Realistic types, as should farmers, mechanics, and foresters: architects, biologists, anthropologists, chemists, and mathematicians are some examples of the Intellectual type and so on and so forth.

Research Studies on the Relationship of Personality and Vocational Choice

Holland's theory of vocational choice (1973) proposes that in-

dividuals tend to choose actual occupational environments consistent with their personal orientations. His theory has generated an extremely large volume of empirical research. Most of the findings have tended to support Holland's theoretical constructs. In one of his first studies, Holland (1962) sampled National Merit finalists over one- and two-year intervals. Using V.P.I. scale scores, vocational choice, or choice of field of study to define a student's type, he reports a broad range of personal characteristics are associated with the types. In a follow-up study, Holland (1963) assessed National Merit finalists (N=592) over a four-year period, using six scales of the Strong Vocational Interest Blank. As well, he defined the students' resemblance to the types by such dependent variables as choice of vocation, major field of study, and self-ratings. His findings support those of his 1962 study, but further, demonstrate that scales other than the V.P.I. can discriminate the types.

Testing some hypotheses about types, Holland (1964), used a sample of bright students (360 boys and 278 girls) to complete a questionnaire that included items about their vocational choices, an adjective checklist, self-ratings, and sentence stems about vocations. The data indicated that students classified as different types according to their V.P.I. scores described themselves in terms congruent with Holland's theory.

One of the major limitations of Holland's studies was the use of the National Merit finalists as their sample population, which limited their general applicability. Therefore the sixth monograph in the series (Holland, 1968) is perhaps the most valuable, since a large sample

of college freshmen from 28 colleges with a wide range of academic talent and social status was employed (1,576 men and 1,571 women). Although the sample was not a representative one, it did allow large-scale test of the theory with a relatively normal group (in contrast to National Merit finalists).

The result of this study extended those of previous studies, with some differences: (1) The results for women were more positive than those for men. In all earlier studies, it had been the other way round. (2) The results were more explicit and substantial. A count of the theoretically expected high mean scores for types and subtypes is as follows: For men, 76 percent are correct across two-letter subtypes, and 64.1 percent are correct across three-letter subtypes. For women, these percentages are 84.0, 75.4, and 72.7, respectively. (3) The overlapping among types remained but seemed less pronounced than before, although no statistical tests were performed. (4) These statistical tests strongly suggested that people with similar codes have similar chracteristics, which means that as we move from comparisons across types to comparisons of subtypes, there will be an obvious increasing similarity of personalities. This is implied by the F tests, which decrease dramatically in size from comparisons across types to comparisons within types.

The six V.P.I. scales used to represent the types are useful for discriminating across educational and vocational groups or occupations. However, the prediction of vocational choice from qualitative data - choice of field of study, employment status, expressed choice of occupation - categorized according to type has usually been more efficient than predictions from the V.P.I.. For a whole sample, the

efficiency of the V.P.I. rarely exceeds 45 percent - a gain of about 28 to 29 percent over the usual expected efficiency. Over eight to twelve months, Holland found that a student's initial choice of occupation, categorized according to type, was about twice as efficient or about 63 to 86 percent for the different types.

Osipow and Wall (1966) show a strong relationship between a student's choice of occupation, his Strong group score, and self-ratings. In a later study, Osipow, Ashby, and Wall (1967), using a sample of 186 male college freshmen, present evidence to support Holland's contention that each personality type seeks out occupational roles seen as consistent with the perception of self. Students rank ordered descriptions of each personality type according to their perceived resemblance to each. The results were then compared to S.V.I.B. group scores, and indicate that students see themselves in ways that correspond with their interest scores.

More recently, Gross and Gaier (1974) sampled 109 college freshmen to re-examine the previously established relationship between vocational choice and self-ratings. Sampled on the basis of major field of study, the subjects completed a questionnaire to select career stereotypes which described them best. Significant relationships were obtained for four stereotypes (Realistic, Conventional, Enterprising, Artistic) on the basis of both field of study and vocational choice. Three of these relationships (Realistic, Enterprising, Artistic) matched those obtained by Osipow and Wall. As predicted, the sample failed to produce a substantial relationship between self-ratings and vocational choice.

Kelso (1969) correlated the California Psychological Inventory (C.P.I.) and the V.P.I. scales for a sample of 188 college males. His findings indicate that students select courses consistent with their personality traits, and that types tend to have personality traits attributed to them. Folsom (1969) assessed a sample of 1,003 college students with the College Student Questionnaire (C.S.Q.) and then compared student types (defined by their choice of major field) on seven scales of the C.S.Q.. The results support the type formulations for all categories except Enterprising. However, Folsom (1971) attempted to replicate Kelso's study by sample 366 high school students and reports that the intercorrelation of the C.P.I. and V.P.I. provide little support for the hypothesized attributes of the types.

Since one of the early criticisms of Holland's theory was the fact that the data base for it was a relatively exclusive, elite population of students, many investigators have tried to extend the theory to more general populations such as high school and community college students, non-college-degreed workers, college-degreed workers, non-college-degreed black working men, and college-degreed working women (Meadows, 1975; Andrews, 1975; Fishburne & Walsh, 1976; Horton & Walsh, 1976; O'Brien & Walsh, 1976; Mount & Muchinsky, 1978; Salomone & Slaney, 1978).

Meadows (1975) explored the extent to which Holland's model of occupational classification could be applied to an inner-city high school population. The subjects studied were 492 high school sophomores (218 male, 274 female) from Region I of the Baltimore

Public School System. The results of statistically treating the data from this study revealed similarities between Holland's findings and the findings of this study. The dominant variables for the male subjects were Realistic, Enterprising, and Conventional, and for female subjects, Social, Artistic, and Conventional.

Andrews (1975) studied 89 male adults enrolled in a community college in an attempt to test Holland's theory of vocational development with an adult population and to expand the theory through the utilization of two subcodes in classification of personality patterns and jobs. The results of the study supported Holland's theory through significant movement on the part of adults toward future environments that are more compatible with their personality types than their present work environments.

Using the V.P.I., Lacey (1971) demonstrates that the typology can be extended to working populations. By assessing a sample of 210 men well established in their occupations, V.P.I. profiles were obtained for eight sub-sample of engineers, chemist, computer programmers, high school teachers, actuaries, executives, and college professors and compared with college students interested in the same field. There were no significant differences between the working group and the college group.

Gaffey and Walsh (1974) explored the concurrent validity of Holland's theory using the V.P.I., the Self-Directed Search (S.D.S.) (Holland, 1972), and the Holland Scales (Campbell & Holland, 1972). The sample, 153 male workers in eight different occupations, consisted of six groups matching Holland's vocational orientations. Subjects had a mean age of 36 years, a mean of 11 working years, and only 10

had no college experience. The results showed five V.P.I. scales, five Holland scales, and four S.D.S. scales successfully differentiated the occupational groups consistent with Holland's theory for a somewhat younger group of workers at a level generally requiring a college.

Salomone and Slaney (1978) also demonstrated the applicability of Holland's theory to nonprofessional workers. Holland's typology was used to classify 470 males and 447 female nonprofessional workers by (1) their present job classification and (2) the personal orientations as measured by the Vocational Preference Inventory. Personality-job congruence was examined, as was the relationship between the workers' self-descriptions of personal characteristics and their personality orientations. The results indicated that nonprofessional workers (1) tended to be congruent with their working environments and (2) tended to perceive groups of adjectives as self-descriptive which were consistent with their personality orientations. Similarly, the results of Mount and Muchinsky (1978) also showed strong empirical support for Holland's hexagonal model with occupational workers in that most subjects were working in environments congruent with their personality types. However there was a lack of empirical support for the proposed relatedness among the environments in the model with regard to person-environment congruence.

Walsh, Horton & Gaffey (1977) investigated differences between men and women employed in traditional male occupations using the Vocational Preference Inventory (V.P.I.) and the Self-Directed-Search (S.D.S.). The V.P.I. and the S.D.S. were administered to 165 male and female college degreed workers in three occupations (engineering,

medicine, and ministry) corresponding to three of Holland's environmental categories (Realistic, Intellectual, and Social). In general, the results for the three V.P.I. and S.D.S. scales and for these occupational groups indicate that men in traditionally male occupations, when compared to women in those same occupations, tend not to report higher mean raw scale scores. The mean raw scores obtained by men and women on the V.P.I. and the S.D.S. scales seemed to be far more similar than different.

Other researchers have attempted to test the validity of the typology for the non-colleged and college-degreed black working men and women. O'Brien and Walsh (1976) explored the concurrent validity of Holland's theory for employed non-college-degreed black men by administering the V.P.I. and the S.D.S. to 121 men workers in occupational environments consistent with Holland's six vocational environments. In general, the findings indicate that the V.P.I. and the S.D.S. scales tend to effectively discriminate among the occupational groups consistent with Holland's theoretical notions. The results tend to suggest that Holland's theory is meaningful for employed non-college-degreed black man.

Yom et al. (1975) factor analyzed the V.P.I. scores for 115 black college students and discovered that the factors revealed were similar for black and whites. Wakefield, Yom, et al. (1975) found an overlap between white students as a result of canonical analysis of black and white students. The data suggest that there are fewer racial differences in vocational variables in the context of Holland's theory than might have been expected.

In sum, most of the past research reviewed lend general support

to the concurrent validity of Holland's theory on personality types and vocational choice, but they have focused on all six types simultaneously. Few studies have researched specific one-letter (high point), two-letter, or three-letter codes. Holland (1973) and Andrews (1975) have recommended that this research is needed.

Research Studies on Engineering Students and Engineers

As can be witnessed by the above section on Personality and Vocational Choice, personality characteristics differentiate individuals in various occupations. The interests and personality traits of engineering students and engineers have been widely researched on.

By administering the Strong Vocational Interest Blank and the Bernreuter Personality Inventory to 237 male freshman Engineers and 166 male freshman Liberal Arts students who entered the Pennsylvania State College in 1940, Goodman (1942) was able to differentiate the engineering students from the Liberal Arts students. Engineering students have been found to be more "stable" and "self-sufficient" than the Liberal Arts students. There is no significant difference between the two groups on the trait of "dominance".

Blum (1947) found Mechanical engineers scored higher on the hysteria scale and appeared to be more introverted than students in education, law, medicine, and journalism. Izard (1960) found engineers significantly higher on achievement, deference, order, dominance, and endurance scales of the E.P.P.S. and lower on affiliation, succorance, intraception, abasement, nurturance and heterosexuality scales than the E.P.P.S. norm group. The differences between the freshman groups were not as great as those between experienced engineers and Edwards' norms. The findings agree rather closely with those of other investigators

utilizing quite different personality assessment techniques (Harrison, Tomblen & Jackson, 1955; Moore & Levy, 1951; Steiner, 1953). Harrison, Tomblen and Jackson utilized projective techniques, objective tests and interview in a study of 100 mechanical engineers whereas Moore and Levy employed projective tests only. They found that engineers have a great involvement with work and a striving for achievement (high Achievement). They rely on authority for settling issues (low Deference). They are fond of structure and order but aversion to ambiguity (high Order). Their social participation is based on conventionality and social conformity rather than any profound interest in people (low Affiliation). There is an avoidance of introspection and self-examination and analytical interest in people is rare. In general, they are self-sufficient (low Succorance), decisive, tough-minded, direct, straightforward and masculine (high Dominance), energetic, goal-oriented, conscientious (high Endurance). They prefer objects and processes to people (low Nurturance).

Beall and Bordin (1964) also confirmed most of the previous findings. Using previous analyses of the activities of engineers and psychometric and interview studies, the following characteristics were found: (1) concentrates on material products and practical outcomes; (2) adopts a clear masculine role and exhibits a strong identification with authority; (3) prefers the planful, orderly, and objective; (4) through specialization finds travel and adventure, shows daring, satisfies mainly impersonal curiosities, augments his physical powers, and acts in manners derivative of the male role.

Engineering students and engineers have been studied by projective

techniques, personal history forms, and clinical interviews, in addition to the previously mentioned paper and pencil tests. While findings show a wide range of temperamental variations, there are definite trends that characterize engineering students and engineers:

1. Engineers are emotionally stable, with interpersonal relations being harmonious but casual. Impersonality is one of their more common traits (Goodman, 1942; Harrison, 1955).
2. The need for analytical interest in people, introspection, and self-examination is rare, with insight being shallow. No great need for affiliation with people is shown. Engineers are relatively insensitive to the less obvious needs of others.
3. Engineers are straightforward, direct, and self-sufficient.
4. Engineers are energetic but are inclined to be matter-of-fact and unimaginative outside their own field (Harrison, Tomblen & Jackson, 1955; Izard, 1960).
5. Engineers are goal-oriented, serious, and conscientious, like things to be ordered and structured (Moore, 1951).
6. Engineers appear very masculine in their interests (Norman, 1952; Beall & Bordin, 1964; Yanico, Hardin & McLaughlin, 1978).
7. Engineering students are higher on sociability, social presence, and communality and lower on feminity, capacity for status, responsibility, achievement, and flexibility than physical science students (Korn, 1962).

However, most studies of occupational choice among college students tend to treat engineering as a single entity. They fail to distinguish among engineering specialties, but rather compare the interests of

students attracted to engineering as a whole with those of students in other fields.

In studies of activity patterns of engineers, Thorndike and Hagen (1959) find differences among the engineering specialties. While civil, electrical, and mechanical engineers are similar, chemical and industrial engineers stand apart, and sales engineers show a pattern least like the other engineering groups. Similarly, Beall and Bordin (1964) using analyzes of the activities of engineers and psychometric and interview studies, found mechanical and aeronautical engineers are similar, that chemical and industrial engineers stand apart, and that both mining and civil engineering have the characteristics of seeking for geographic mobility. Both mechanical and aeronautical engineers experience the augmenting of their own power through the designing and construction of machines. Chemical and industrial engineers are much concerned with processing, the former with materials and the latter with the interrelations of men and materials.

However, Pietrofesa (1970) found engineering students to possess similar personality-need patterns regardless of engineering specialty. Male engineers had a high need for achievement, endurance, and order, while demonstrating a low need for affiliation. Cohen and Derrick (1970) pointed out that courses of undergraduate and professional training in civil and electrical engineering differ considerably in the nature, scope and content of their respective fields of scientific enquiry. The mature and successful practioners of both professions, however, are in substantial agreement on what they desire from their careers and on the personal attributes which they perceive as

necessary to attain their goals.

In a recent study, Izraeli, Krausz and Garber (1979) support the proposition that "engineers should not be lumped together into a single category" (Dunnette et al., 1964, p.492). Engineers do not form a homogenous category because engineering, like other professions, is not homogenous. It is rather, as Bucher and Strauss (1961) have suggested, "an amalgamation of segments," characterized by different objectives, activities, values, and interests, "more or less delicately held together under a common name, at a particular period in history" (Bucher & Strauss, p.326). Such a perspective on professions has implications for the matching hypothesis of occupational choice. Instead of examining the characteristics of persons gravitating toward engineering, one should inquire into what types of person select which types of engineering.

Webster, Winn and Oliver (1951), Sauders (1954) and Dunnette and England (1957) were some of the early investigators who initiated the study of engineers on their job duties. Dunnette, Wernimont, and Abrahams (1964) state that regardless of the engineering specialty the engineer may engage in any one of four engineering job duties: Basic Research (investigating problems of a fundamental nature and developing and testing hypotheses); Applied Research and Development (developing working models and completing experimental and pilot projects); Production and Process Engineering (planning efficient use of equipment and materials, simplifying production methods and controlling expenses); and Sales and Technical Service Engineering

(working with customers' representatives, selling ideas to people, and keeping informed about competitive products and activities). These four job duties are relatively independent of one another (Saunders, 1954; Dunnette & England, 1957) and it has been shown that engineers in these various functions differ from one another in interest patterns on performance on personality tests (Webster, Winn & Oliver, 1951; Dunnette, 1957; Kirchner & Dunnette, 1958; Kulberg & Owens, 1960; Gough, 1961; Medvene & Shueman, 1978; Taylor, 1979). Webster, Winn and Oliver (1951) by administering the Strong Vocational Interest Blank (S.V.I.B.) to groups of research engineers and sales engineers employed with the Aluminium Company of Canada found that research engineers obtained highest scores in Human and Technical Science occupations; sales engineers, as might be expected, obtained highest scores in the Sales occupation. Similarly, Dunnette, Vernimont & Abraham (1964) by developing special R, D, P & S keys for the S.V.I.B. and administering Minnesota Engineering Analogies Test (M.E.A.T.), the California Psychological Inventory (C.P.I.) and the Allport Vernon Lindzey Scale of Values (A.V.L.) found that Research engineers appear most interested in intellective, conceptualizing, or theorizing activities, Development engineers appear most interested in engineering work per se and also show a more "practical" orientation as reflected in their interest in mathematics and industrial arts teaching. Production engineers seem most interested in the administration and/or control of resources - human, material, and financial. And Sales engineers reflect an obviously strong interest in people, particularly in the manipulation of other persons through

verbal or mass persuasion techniques. Medvene and Shueman (1978) who focused on the perceived parental attitudes and choice of vocational specialty and job functions found that students choosing a Sales and Technical Service job function (defined as people oriented) are more likely to describe their dominant parent as Accepting, while those in the other three function groups, namely, Basic Research, Applied Research and Development, Production and Process Engineering (defined as non-person oriented) are more likely to describe their dominant parents as Avoiding.

However, in the past research, no attempt has ever been made to use the Vocational Preference Inventory, a comparatively less expensive, "straightforward, easy to administer and score, non-threatening" (Holland, 1975) and requiring less time to complete, psychological inventory to differentiate the four major job duties on engineers with the aim of providing the vocational counselors or employment interviewer with important information concerning the appropriate job placement of graduating engineers. It is, therefore, part of the objectives of this investigation to study the discriminatory power of the Vocational Preference Inventory to differentiate engineers of different job duties.

Research Studies on Personality Change

Holland's theory has been applied to the person-environment interactions of college students on the notion that personality patterns that are consistent with the intended occupational environment forecast stability of vocational choice and achievement. Holland (1963, 1968) shows that the consistency of a student's personality (according

to V.P.I. profile) is positively related to the stability of a student's vocational choice or choice of major field over one- to four-year intervals. The results, however, are generally inconclusive. In similar studies, Hughes (1971) reports negative results while Kernen (1971) reports inconsistent findings.

Brown (1966) suggests that different kinds of peers provide different kinds of reinforcement. Brown's experiment with students living in a dormitory provides evidence that peers influence a student's tendency to maintain or change vocational goals, dependent on consistency of personality patterns. This study would lead one to believe that the majority type in a population could manipulate types in the minority to either withdraw from an inconsistent environment or change their personality to a pattern congruent with the environment. Holland (1968) however, sampling 2,347 college students at 27 colleges, obtained data which failed to support the hypothesis that students will maintain their vocational choice when surrounded with peers whose choices belong to the same type.

Elton (1971), however, provides positive evidence that students who leave a particular environment tend to undergo personality change that makes them different from students who remain in the environment. Engineering students transferring to arts and sciences become more realistic, non-judgmental, intellectually liberal, and skeptical of orthodox religious beliefs. Comparisons of university students with students in two-year college implied similar expected environmental effects.

Taylor and Hanson (1972) using multiple discriminant to analyze the Strong Vocational Interest Blank profiles of 77 persisters and 39

transfers who had taken the S.V.I.B. in the fall of 1966 and again in the spring of 1969 found that transfer S.V.I.B. profiles indicated a major change with a loss of physical science interest and an increased interest in social service, business management, and sales. The S.V.I.B. profiles of persister and transfer students showed extensive differences after 3 years.

Similarly, in a study limited to investigative types, O'neil (1975) found that college students who resembled the investigative types, according to their Self-Directed Search profiles, more often expressed investigative preferences 4 years later if their profiles were consistent rather than inconsistent. As part of a larger study, Holland et al. (1973) studied men whose first full-time jobs were in the realistic category and found that men with consistent occupational codes were more likely to be employed in realistic work 5 or 10 years later. Nafziger et al. (1974) also found that consistency of earlier jobs was related to categorical stability for white men, but not for black men. Gottfredson (1977) basing on a large sample of 21- to 70-year-old men and women workers using Holland's occupational classification found that career stability increased with age for both sexes and age differences persisted even when the analyses were restricted to occupation changers or socioeconomically mobile workers. People initially employed in consistent occupation were more stable than those initially employed in inconsistent occupations.

Walsh and Lacey (1969, 1970) examined how student personalities change over a four-year college term by having students estimate how they changed on adjective rating scales. The results suggest that student personalities become more stereotyped over a four-year

college program. In a similar study, Walsh, Vaudrin, and Hummel (1972) find that senior report more change consistent with their personality than freshmen.

However, in an attempt to evaluate the effects of environment upon students, Privateer (1971) examined the effects of a college environment upon entering freshmen. Six hundred freshmen were assessed with the V.P.I. on entry and again in eight months. Results show a student's congruence with his environment was not significantly different over this time period. Gile's study (1975) in administering the V.P.I. to 409 two-year college students also failed to support the question of stereotype changes at various stages of occupational preparation as predicted by Holland (1973).

Summary

The review of literature indicates, then, that: (1) Holland's theory proposing that individuals tend to choose actual environments consistent with their personality types is generally supported, (2) Engineering students and engineers are generally found to be "emotionally stable, self-sufficient, goal-oriented, serious, and conscientious" and that engineers in different job duties tend to have different personalities, but there are conflicting findings on personality traits of engineering students or engineers in different specialties, and (3) the personality of students becomes more stereotyped with the type demanded by a particular environment over a period of time though with a few exceptions.

Hypotheses

In the present study, the following hypotheses stated in null

form are to be tested:-

Hypothesis 1

There are no significant differences in mean raw scores for engineering students and engineers.

Hypothesis 2

There are no significant differences in mean raw scores for second and fourth year engineering students and engineers.

Hypothesis 3

There are no significant differences in mean raw scores for second year engineering students and engineers.

Hypothesis 4

There are no significant differences in mean raw scores for fourth year engineering students and engineers.

Hypothesis 5

There are no significant differences in mean raw scores for second and fourth year engineering students.

Hypothesis 6

There are no significant differences in mean raw scores for engineers in high, middle and young age groups.

Hypothesis 7

There are no significant differences in mean raw scores for engineers who have considered change of occupation and those who have not.

Hypothesis 8

There are no significant differences in mean raw scores for Chemical, Civil, and Mechanical Engineers.

Hypothesis 9

There are no significant differences in mean raw scores for Chemical and Civil Engineers.

Hypothesis 10

There are no significant differences in mean raw scores for Chemical and Mechanical Engineers.

Hypothesis 11

There are no significant differences in mean raw scores for Civil and Mechanical Engineers.

Hypothesis 12

There are no significant differences in mean raw scores for Chemical, Civil, and Mechanical Engineering Students.

Hypothesis 13

There are no significant differences in mean raw scores for Chemical and Civil Engineering Students.

Hypothesis 14

There are no significant differences in mean raw scores for Chemical and Mechanical Engineering Students.

Hypothesis 15

There are no significant differences in mean raw scores for Civil and Mechanical Engineering Students.

Hypothesis 16

There are no significant differences in mean raw scores for Development, Sales and Production Engineers.

CHAPTER III

METHODOLOGY

The Sample

The sample consisted of 128 male students registered either in their second or fourth year of studies in Chemical, Civil, or Mechanical Engineering at University of Alberta, and 74 male Chemical, Civil, and Mechanical engineers currently working in the city of Edmonton, Alberta. A random sample of 275 second or fourth year Chemical, Civil, or Mechanical engineering students was drawn from the Engineering Student List (1980) furnished by the Faculty of Engineering, University of Alberta. The engineering firms of the three specialties were randomly selected from the telephone directory and invited to participate in this study by phone call. Tables 1 and 2 present the analysis of sample. N represents the number of engineering students or engineers who have completed the Vocational Preference Inventory (V.P.I.) which are usable.

Subjects were chosen in second or fourth year of studies in Chemical, Civil, and Mechanical Engineering for the purpose of stage comparison of personality patterns. Three age groups were formed among engineers in which subjects aged 41 or over (N=18) were classified as a high age group. Subjects between the ages of 31 and 40 were considered as a middle age group (N=21), and subjects between 19 and 30 (N=35) were classified as a young age group. They were chosen to investigate any age-related change in personality patterns.

Three specialties, namely, Chemical, Civil, and Mechanical were chosen for cross comparison of personality patterns. Since there was

TABLE 1

ANALYSIS OF SAMPLE BY SPECIALTIES AND YEAR OF STUDIES

Specialties	Year II N	Year IV N	Total N
Chemical Engineering Students	24	12	36
Civil Engineering Students	23	21	44
Mechanical Engineering Students	25	23	48
Chemical Engineers	-	-	16
Civil Engineers	-	-	36
Mechanical Engineers	-	-	22
Total	72	56	202

TABLE 2

ANALYSIS OF SAMPLE BY AGE

	ENGINEERING STUDENTS		ENGINEERS	
Age Group	Frequency	Percent	Frequency	Percent
16-18	2	1.6	0	0.0
19-22	99	77.3	4	5.4
23-30	26	20.3	31	41.9
31-40	0	0.0	21	28.4
41 or over	1	0.8	18	24.3
Total	128	100.0	74	100.0

only one Basic Research engineer in the sample, he was not included for analysis. Therefore, only three groups were formed among engineers of different job duties, namely, Development (N=6), Sales (N=4), and Production (N=63) for cross comparison of personality patterns.

Lastly, for comparison of consistency of personality type and environment and change of occupation, two groups, namely, those who have considered change of occupation (N=18) and those who have not (N=56), were formed among engineers.

The Instruments

Two general questionnaires (X & Y) and the Vocational Preference Inventory (V.P.I.) were used in the study. The V.P.I. was used to obtain scores on Holland's six personality types.

The Questionnaires Questionnaire X (Appendix B) was designed to gather some demographic data for classification purpose, information on satisfaction with present occupation, consideration of change of occupation, and degree of confidence or confusion in the choice of engineering program at university from the engineers. Question #1 was for sex identification as this study would only sample male engineers for investigation. Question #2 was for grouping engineers into different age groups to examine if there was any age-related personality change. Questions #2, 5, 7 and 8 were included for cross-validation of information and to examine whether there were any relationships among the four variables. The inclusion of Question #4 was to determine whether there were any differences in personality patterns of engineers in different specialties. Question #6 was included to study whether there were

any differences in personality patterns among engineers in different job duties. According to Dunnette, Wernimont, and Abraham (1964), there were four different engineering job duties: Basic Research (investigating problems of a fundamental nature and developing and testing hypotheses); Applied Research and Development (developing working models and completing experimental and pilot projects); Production and Process Engineering (planning efficient use of equipment and materials, simplifying production methods and controlling expenses); and Sales and Technical Service (working with customers' representatives, selling ideas to people, and keeping informed about competitive products and activities). Lastly, the last four questions, namely #9 to #12 were included to see if there were any differences in personality patterns of engineers who have considered change of occupations and those who have not and what their preferences would be if they had considered changing to other occupations. There were similar criteria for inclusion of questionnaire items for Questionnaire Y (Appendix C) which was designed to gather some demographic data for classification purpose, information on satisfaction with present program and degree of confidence or confusion in the choice in engineering program at university from the engineering students.

The Vocational Preference Inventory: Description The Vocational Preference Inventory (1977), is a personality and interest inventory, composed of 160 occupational titles covering a broad range from pilot through building wrecker to army general. The subject is instructed to indicate on the answer sheet which

occupations interest or appeal to him/her, and which he/she dislikes or finds uninteresting. He/She is instructed to make no response when he/she is undecided.

The inventory is composed of eleven scales: Realistic, Intellectual, Social, Conventional, Enterprising, Artistic, Self-Control, Masculinity, Status, Infrequency and Acquiescence. The first six scales as described in Chapter II represent the personal orientations, while the other five scales provide a means of evaluating the subject's test-taking consistency. The Self-Control scale reflects the degree of spontaneity in living; the Masculinity scale indicates occupational roles identified with males and females; the Status scale indicates vocational choices in terms of prestige ranking; the Infrequency scale, actually a Social Desirability scale, indicates the subject's choices in terms of typical and popular likes and dislikes; the Acquiescence scale, a fakeability scale, detects dissimulation and extreme response biases.

Each of the first nine scales consists of 14 overlapping items, yielding a raw score range from 0 to 14. From the first six scales, Holland obtains a profile of the ranking of the six personality categories. The higher a person's score on a scale, the greater his/her resemblance to the type that scale represents. His/Her highest score represents his/her personality "type", his/her profile of scores (obtained by ranking the scale scores from highest to lowest) represents his/her personality "pattern". The Infrequency scale consists of 20 items, yielding a raw score range from 0 to 20, and the Acquiescence scale of

30 items, and from 0 to 30 respectively.

In the present study, only the first six scales were used. The personality "type" denoted by the Occupations Finder (Holland, 1977) for Chemical and Civil Engineers is "Intellectual" whereas for Mechanical Engineers is "Realistic". The personality "pattern" presented in Occupations Finder (Holland, 1977) for Chemical and Civil Engineers is "IRE", and Mechanical Engineer is "RIE".

The Vocational Preference Inventory: Reliability The V.P.I. Manual (Holland, 1975) reports internal consistency coefficients (Kuder-Richardson formula 21) ranging from .83 to .89 for 6,289 male college students and from .76 to .88 for 6,143 female college students for the first six "personality type" scales, and from .57 to .86 and from .50 to .85 respectively for the male and female samples for the remaining scales. Retest reliability coefficients for Kansas State Freshmen (N=26) over a one-year period, are reported as from .61 to .86, while coefficients for National Merit finalists, male (N=432) and female (N=204) over a four-year period, range from from .47 to .61 and .45 to .56 respectively for the "type" scales. This low reliability over time could be a function of personality change, or perhaps, because of the somewhat extreme nature of the sample, of regression toward the mean.

The Vocational Preference Inventory: Validity Studies on the validity of the V.P.I. have presented supporting evidence as well. Hasse (1971, p.182) correlated the six V.P.I. scales and 47 scales of the Strong Vocational Interest Blank (S.V.I.B.) and found "..... 100% of the trace was extracted by six

canonical roots." The six correlations for a sample of 176 male college students ranged from .66 to .86. Hasse concludes "....the V.P.I. and S.V.I.B. measure similar dimensions." (p.183). Lee and Hedahl (1972) categorized 432 male college freshmen according to their V.P.I. high-point code and compared them to the Basic Interest (B.I.) scales of the S.V.I.B.. They found the B.I. scales discriminated among the types with moderate efficiency. In fact, 21 of the 22 F-tests and 19 of the Scheffe multiple comparisons among the means were significant. These findings receive further support from Cole and Hansen (1971) whose work shows high internal structural relationships of scales from the S.V.I.B. and the V.P.I.. Using the V.P.I., S.V.I.B., and the 16 P.F., Hughes (1971) categorized working males as types by using their occupations. He tested what characteristics were found for what types and reports the V.P.I. placed 42% of the men in correct occupational categories, the S.V.I.B. placed 14% to 35%, the 16 P.F. placed 23% correctly. Campbell (1971) created six V.P.I. scales for the S.V.I.B. by using definitions of the personality types and lists of occupational titles reported by Holland. Rescoring the Strong criterion groups of employed adults for a sample of 76 occupations, the Campbell form of the V.P.I. and V.P.I. agreed on the main classification of occupation 84% of the time. Campbell apparently feels that the V.P.I. is a creditable instrument in that computerized profiles of the S.C.I.I. now include a listing of the six V.P.I. scales as "General Occupational Themes" (S.C.I.I. Form T325).

Williams (1972) assessed 145 male graduate students, sorted

according to Holland's types, by using the V.P.I., 16 P.F., and the Allport-Vernon-Lindzey Study of Values (A.V.L.). His findings indicate the V.P.I. correctly identified 93 of 145 students, while the 16 P.F. identified 83 of 145, and the A.V.L. 67 of 145. However, in a similar study by Harvey (1971), using the V.P.I., selected scales of the S.V.I.B., the E.P.P.S., the A.V.L. and the D.A.T., he reports moderate relationships between types and their assumed characteristics, but some inconsistencies were observed.

In studies of vocation aspiration, the V.P.I. has been found to be predictive of choice of major field and occupation over one- and two-year intervals for both students of average and high aptitude (Holland & Lutz, 1968; Holland, 1962). The efficiency of these predictions is only moderate, ranging from 35 to 60 percent accuracy. Other investigators have produced conflicting results. Southworth and Morningstar (1970) using discriminant function, predicted persistence in engineering over a two-year interval with moderate success. Wall (1969) was able to distinguish engineering from other majors but failed to predict persistence in engineering. Using special short form of the V.P.I. (66 items for 10 scales), Krulee, O'Keefe, and Goldberg (1966) found that even grossly abbreviated V.P.I. scales would discriminate students from those who transferred to other fields.

Data Collection and Scoring

147 research packets containing General Instructions (Appendix A), Questionnaire X (Appendix B), the V.P.I. and its accompanied answer sheet were sent to Chemical, Civil and Mechanical engineering firms

previously invited to participate in this study by phone calls. Another research packets containing General Instructions (Appendix A), Questionnaire Y (Appendix C), the V.P.I. and its accompanied answer sheet were sent to 275 second or fourth year Chemical, Civil and Mechanical engineering students randomly drawn from the Engineering-Student List (1980) furnished by the Faculty of Engineering, University of Alberta. Subjects were asked to complete the questionnaire and the V.P.I.. A follow-up phone call was made to the non-respondents five weeks after the packets were sent. Completed packets were returned in a self-addressed stamped envelope provided. A total of 164 and 97 packets were received from the engineering student group and the engineering group respectively. The V.P.I. and the questionnaire were handscored. 36 subjects from the engineering student group were eliminated from further analysis because of missing data and extreme response detected by the scales as outlined in the Manual (Holland, 1975, pp.8,9) leaving 128 for further analysis, while in the engineering group, 23 subjects were eliminated, leaving 74 for further analysis.

Analysis of Data

The data collected on each subject from the questionnaire and their raw scores on each of the first six scales were entered into computer for programmed statistical analysis. All hypotheses were tested across all six scales using one-way multivariate analysis of variance for unequal Ns (Finn, 1974) with the computer program MUL16 (DERS, University of Alberta, 1980). This procedure included a 95 percent simultaneous confidence intervals on pairwise differences of each scale. Chi-square contingency test (Johnson & Jackson, 1959) was also used for Hypotheses 5 and 7. An one-way analysis of variance was also used for

further analysis of some of the statistically significant hypotheses.

CHAPTER IV

RESULTS

Hypothesis 1

There are no significant differences in mean raw scores for engineering students and engineers.

The means, variances, and multivariate analysis of variance are shown in Tables 3 and 4 respectively.

As indicated in Table 4, a significant difference was found between the engineering student group and the engineering group at the 0.05 level of significance according to the Wilks' Lambda test ($F=2.85$, $df=6/195$, $p<0.05$). Therefore, the null hypothesis is rejected.

To determine which dependent variable difference or dependent variables' differences contributed to the rejection of this hypothesis, the 95 percent simultaneous confidence intervals on pairwise differences were constructed. The results of these multiple comparisons are summarized in Table 5. Since the confidence intervals for the six comparisons contain 0, there is no significant difference at the 0.05 level for the six comparisons.

A one-way ANOVA was applied to the same data for further analysis. The results as presented in Table 6 show that there is a significant difference in the Realistic and Social scales for the two groups ($F=13.01$, $df=1/200$, $p<0.001$; $F=5.50$, $df=1/200$, $p<0.05$), while the other four scales reveal no significant difference.

Figure 1 presents the V.P.I. profiles of the engineering student

TABLE 3

MEANS AND VARIANCES, V.P.I. SCALES
OF ENGINEERING STUDENTS AND ENGINEERS

V.P.I. Scales	ENGINEERING STUDENTS (N=128)		ENGINEERS (N=74)	
	Mean	Variance	Mean	Variance
Realistic	4.64	9.57	6.35	11.96
Intellectual	5.39	13.39	6.43	13.54
Social	1.73	6.20	2.70	10.88
Conventional	2.22	6.17	2.57	5.54
Enterprising	3.67	9.61	3.89	10.34
Artistic	2.98	11.48	3.78	14.17

TABLE 4

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF ENGINEERING STUDENTS AND ENGINEERS

Wilks' Lambda	0.92
F	2.85
df	6/195
p	0.0115*

* $p<0.05$

TABLE 5

SUMMARY OF THE MULTIPLE COMPARISONS
BETWEEN ENGINEERING STUDENTS AND ENGINEERS*

V.P.I. Scales	Mean Difference	Confidence Interval
Realistic	1.71	-0.013 to 3.434
Intellectual	1.04	-0.913 to 2.997
Social	0.97	-0.531 to 2.468
Conventional	0.35	-0.951 to 1.648
Enterprising	0.22	-1.456 to 1.896
Artistic	0.80	-1.083 to 2.682

* $\alpha=0.05$

TABLE 6

ONE-WAY ANOVA
OF ENGINEERING STUDENTS AND ENGINEERS

V.P.I. Scale	Source	SS	MS++	F	P
Realistic	Between Group	137.23	137.23	13.01	0.0003***
	Within Group	2110.33	10.55		
Intellectual	Between Group	50.89	50.89	3.75	0.0543
	Within Group	2716.63	13.58		
Social	Between Group	43.97	43.97	5.50	0.0199*
	Within Group	1598.43	7.99		
Conventional	Between Group	5.71	5.71	0.95	0.3306
	Within Group	1200.04	6.00		
Enterprising	Between Group	2.27	2.27	0.23	0.6339
	Within Group	1995.35	9.98		
Artistic	Between Group	29.97	29.97	2.38	0.1245
	Within Group	2518.51	12.59		

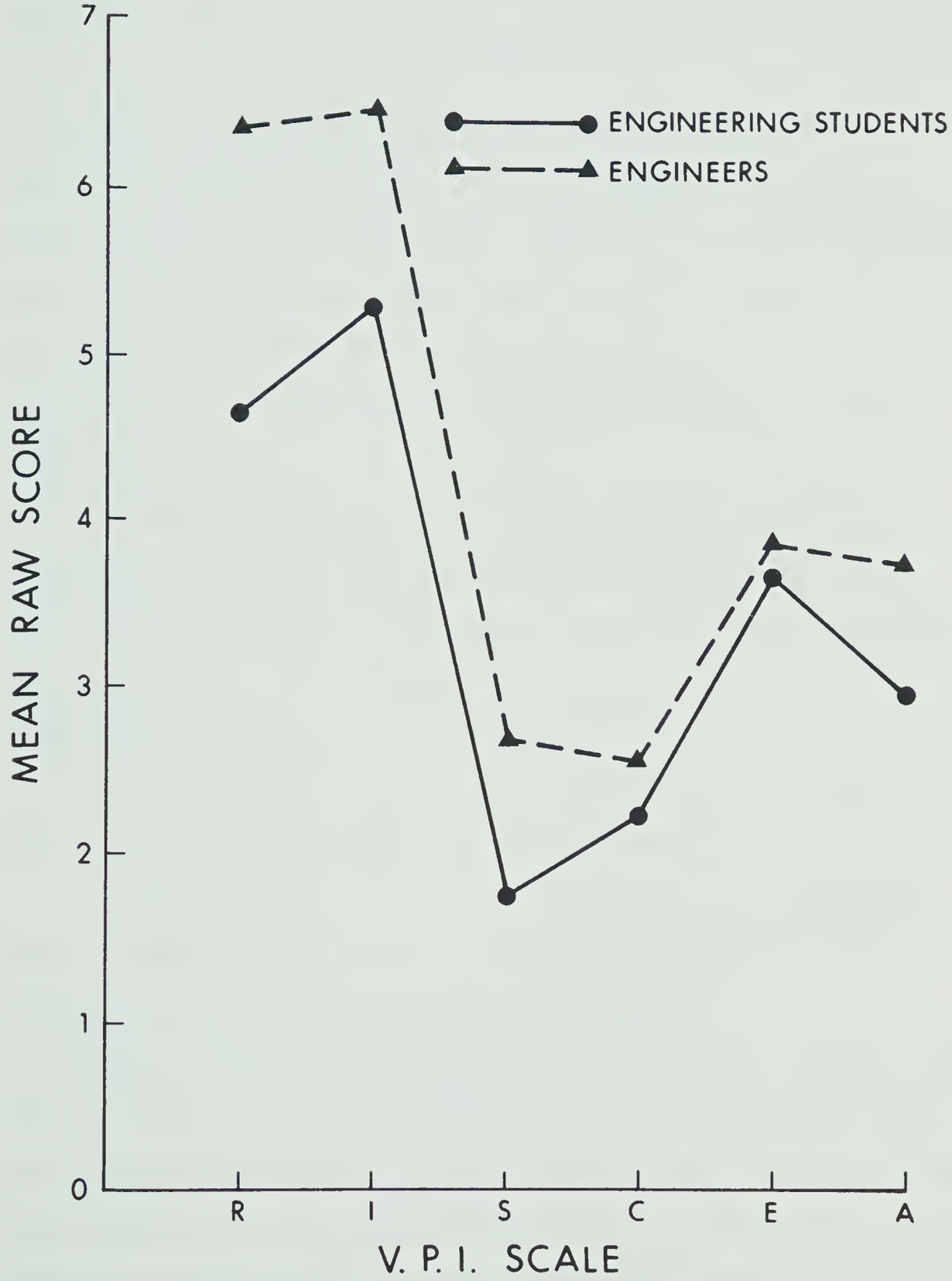
++ df=1/200

* $p<0.05$

*** $p<0.001$

FIGURE 1

V. P. I. PROFILES OF
ENGINEERING STUDENTS & ENGINEERS



and engineering groups. The overall shapes of the two curves are quite similar with the engineering group having a comparatively higher mean scores in all six of the scales. Both groups show marked elevations on the Realistic and Intellectual scales, lesser elevation on Enterprising, and a depression on the Social and Conventional scales. The patterns of general similarity suggests that the personality patterns of the engineering student group in their preparation stage are rather consistent though significantly different. It is interesting to note that both have the same personality pattern "IRE" derived from the three highest V.P.I. mean raw scores, as suggested by Holland (1977).

It appears, therefore, that there is an overall significant difference in personality patterns between the engineering student group and the engineering group with the engineering group comparatively higher on the Realistic and Social scales.

Hypothesis 2

There are no significant differences in mean raw scores for second and fourth year engineering students and engineers.

The means, variances, and multivariate analysis of variance are shown in Tables 7 and 8 respectively. Table 8 reveals no significant difference for the three groups at the 0.05 level.

Figure 2 presents the V.P.I. profiles for the three groups. The overall shapes of the three curves are quite similar with engineering group having higher scores in five of the six scales. The first three highest mean raw scores which constitute their respective personality patterns are Intellectual, Realistic, and Enterprising "IRE" for the

TABLE 7

MEANS AND VARIANCES, V.P.I. SCALES
OF SECOND AND FOURTH YEAR ENGINEERING STUDENTS AND ENGINEERS

V.P.I. Scales	ENGINEERING STUDENTS				ENGINEERS	
	Year II (N=72)		Year IV (N=56)		(N=74)	
	Mean	Variance	Mean	Variance	Mean	Variance
Realistic	4.58	9.88	4.71	9.17	6.35	11.96
Intellectual	5.25	13.13	5.57	13.67	6.43	15.54
Social	1.67	5.06	1.82	7.65	2.70	10.88
Conventional	2.42	6.97	1.96	5.03	2.57	5.54
Enterprising	3.92	11.83	3.36	6.59	3.89	10.34
Artistic	2.72	10.76	3.32	12.22	3.78	14.17

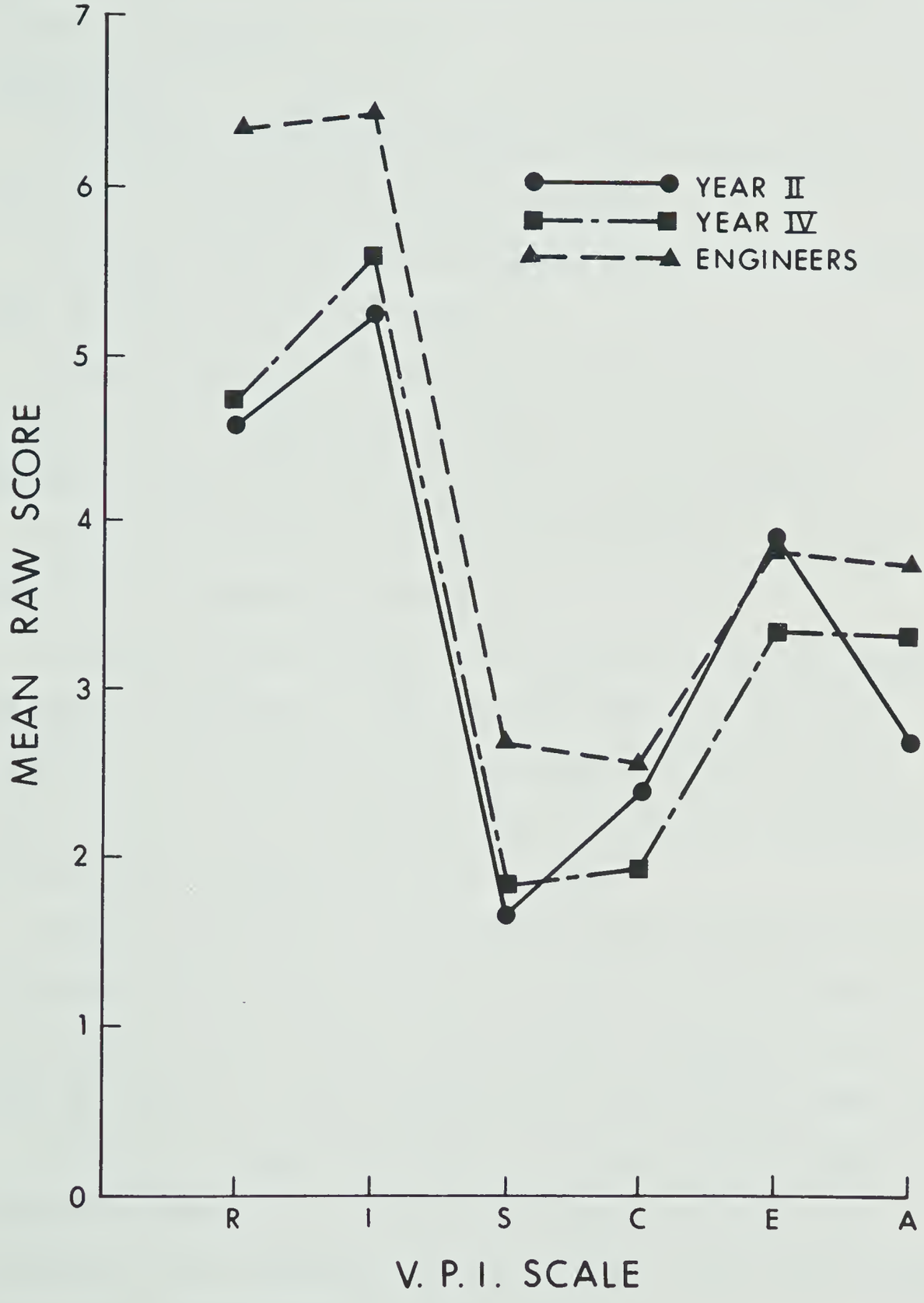
TABLE 8

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF SECOND AND FOURTH YEAR ENGINEERING STUDENTS AND ENGINEERS

Wilks' Lambda = 0.91
F = 1.63
df = 12/388
p = 0.08

FIGURE 2

V. P. I. PROFILES OF SECOND & FOURTH YEAR ENGINEERING STUDENTS & ENGINEERS



three groups.

In sum, it appears that there is no significant difference in personality patterns for the second and fourth year engineering students and engineers.

Hypothesis 3

There are no significant differences in mean raw scores for second year engineering students and engineers.

The means, variances, and multivariate analysis of variance are shown in Tables 7 and 9 respectively.

The null hypothesis was rejected. There was a significant mean difference for the second year engineering student group and the engineering group at the 0.05 level ($F=2.52$, $df=6/139$, $p<0.05$).

Table 10 shows there is no significant difference at the 0.05 level for the six pairwise comparisons.

A one-way ANOVA was applied to the same data for further analysis. The results as presented in Table 11 show there is a significant difference in the Realistic and Social scales ($F=10.29$, $df=1/144$, $p<0.01$; $F=4.82$, $df=1/144$, $p<0.05$), while the other four scales reveal no significant differences for the two groups.

Figure 3 presents the V.P.I. profiles of the two groups. The overall shapes of the two curves are rather similar with the engineering group having higher scores on five of the six scales, presenting the personality pattern of a typical engineer "IRE" predicted by Holland (1977).

To sum up, it appears that there is a significant difference in personality patterns for the second year engineering students and the engineers with the engineering group having a significantly higher score both in the Realistic and Social scales.

TABLE 9

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF SECOND YEAR ENGINEERING STUDENTS AND ENGINEERS

Wilks' Lambda	= 0.90
F	= 2.52
df	= 6/139
p	= 0.02*

*$p \leq 0.05$

TABLE 10

SUMMARY OF THE MULTIPLE COMPARISONS
BETWEEN SECOND YEAR ENGINEERING STUDENTS AND ENGINEERS*

V.P.I. Scales	Mean Difference	Confidence Interval
Realistic	1.77	-0.254 to 3.790
Intellectual	1.18	-1.050 to 3.415
Social	1.04	-0.694 to 2.766
Conventional	0.15	-1.377 to 1.679
Enterprising	-0.02	-2.059 to 2.010
Artistic	1.06	-1.099 to 3.222

* $\alpha = 0.05$

TABLE 11

ONE-WAY ANOVA
OF SECOND YEAR ENGINEERING STUDENTS AND ENGINEERS

V.P.I. Scale	Source	SS	MS++	F	P
Realistic	Between Group	114.07	114.07	10.29	0.0017**
	Within Group	1596.37	11.09		
Intellectual	Between Group	51.02	51.02	3.77	0.0541
	Within Group	1947.66	13.53		
Social	Between Group	39.17	39.17	4.82	0.0297*
	Within Group	1169.46	8.12		
Conventional	Between Group	0.83	0.83	0.13	0.7177
	Within Group	911.66	6.33		
Enterprising	Between Group	0.02	0.02	0.00	0.9644
	Within Group	1616.64	11.23		
Artistic	Between Group	41.12	41.12	3.25	0.0736
	Within Group	1822.98	12.66		

++df=1/144

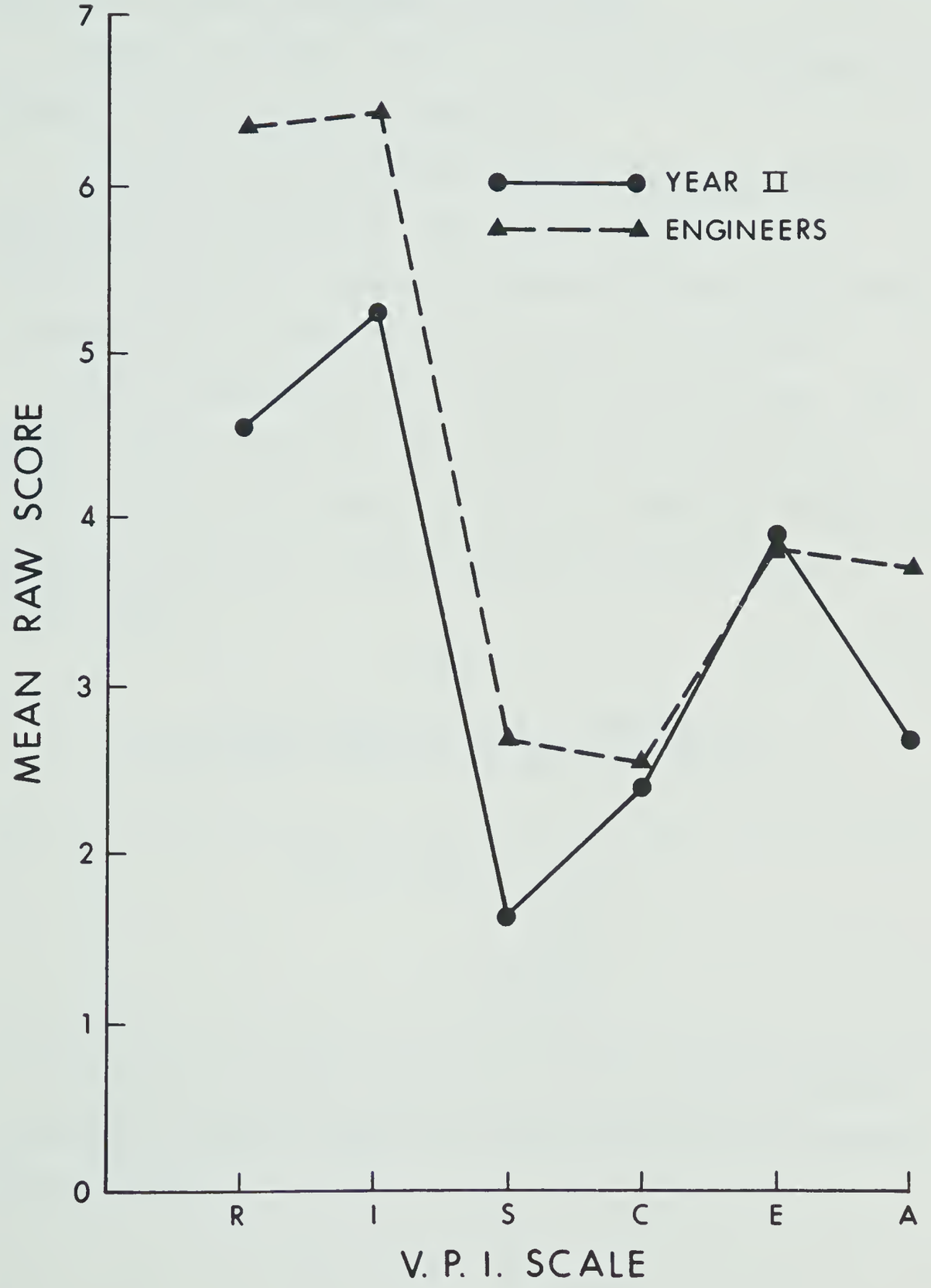
* $p<0.05$

** $p<0.01$

FIGURE 3

V. P. I. PROFILES OF

SECOND YEAR ENGINEERING STUDENTS & ENGINEERS



Hypothesis 4

There are no significant differences in mean raw scores for fourth year engineering students and engineers.

The means, variances, and multivariate analysis of variance are presented in Tables 7 and 12 respectively.

The results of the one-way multivariate analysis of variance supported the null hypothesis. There was no significant mean difference between the fourth year engineering students and engineers in terms of the six scales at the 0.05 level of significance.

Figure 4 presents the V.P.I. profiles of the two groups. The overall shapes of the two curves are quite similar with the engineering group scoring higher on all the six scales, presenting the personality pattern of a typical engineer "IRE" predicted by Holland (1977).

TABLE 12

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF FOURTH YEAR ENGINEERING STUDENTS AND ENGINEERS

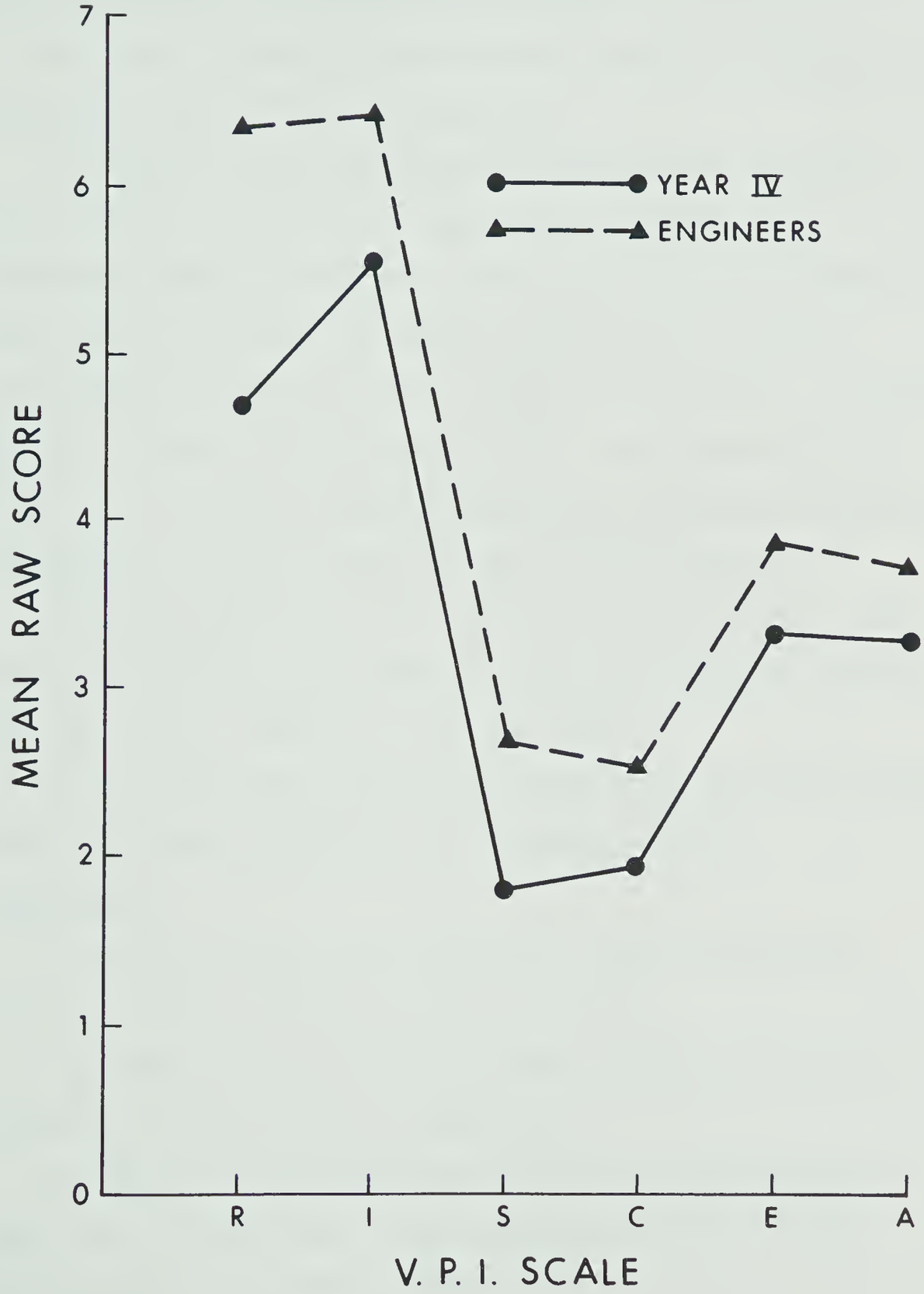
Wilks' Lambda = 0.92
F = 1.73
df = 6/123
p = 0.12

It appears, therefore, that there is no significant difference in personality patterns between the fourth year engineering students and the engineers.

FIGURE 4

V.P.I. PROFILES OF

FOURTH YEAR ENGINEERING STUDENTS & ENGINEERS



Hypothesis 5

There are no significant differences in mean raw scores for the second and fourth year engineering students.

The means, variances, and multivariate analysis of variance are presented in Tables 7 and 13 respectively.

The results of the one-way multivariate analysis of variance supported the null hypothesis. There was no significant mean difference between the second and fourth year engineering students in terms of the six scales. Chi-square analysis shown in Table 14 presenting the number of students observed high-point score consistent and not consistent with the expected score "Intellectual" (Holland, 1977) also confirmed the null hypothesis of no significant difference between the two groups at the 0.05 level of significance.

Figure 5 presents the V.P.I. profiles of the two groups. They share similar profiles with identical personality patterns consistent with the one "IRE" predicted by Holland (1977).

In sum, there is no significant difference in personality patterns between the second and fourth year engineering students.

Hypothesis 6

There are no significant differences in mean raw scores for engineers in high, middle, and young age groups.

The means, variances, and multivariate analysis of variance are presented in Tables 15 and 16 respectively.

The results of the multivariate analysis of variance tend to support the null hypothesis. No significant difference in mean raw scores was found among the three groups.

TABLE 13

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF SECOND AND FOURTH YEAR ENGINEERING STUDENTS AND ENGINEERS

Wilks' Lambda	= 0.98
F	= 0.44
df	= 6/121
p	= 0.85

TABLE 14

CHI-SQUARE ANALYSIS*

Predicted Type (Intellectual)	Engineering Students Year II	Year IV	X^2
consistent	28	17	1.01
not consistent	44	39	

*α = 0.05

FIGURE 5

V. P. I. PROFILES OF
SECOND & FOURTH YEAR ENGINEERING STUDENTS

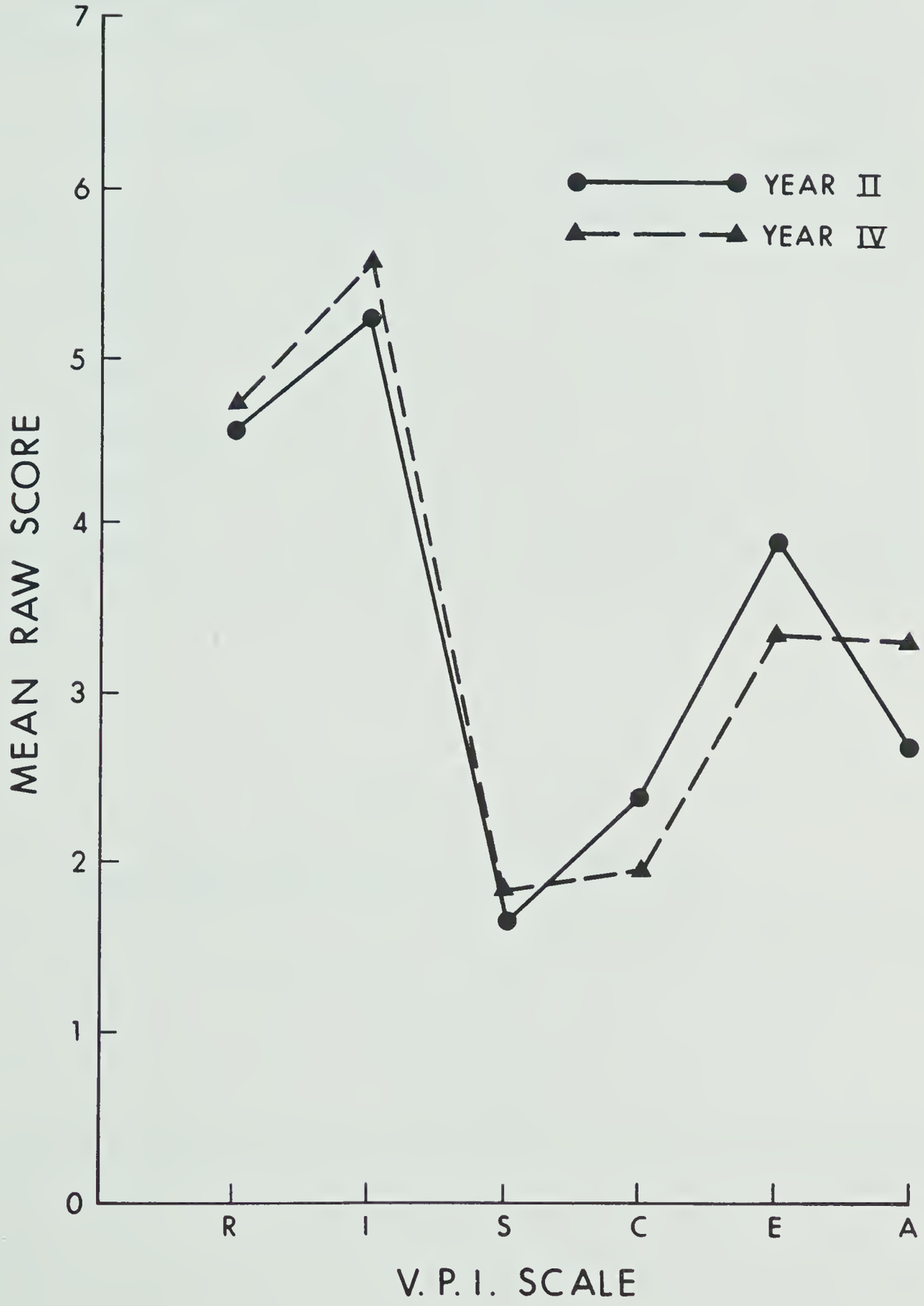


TABLE 15

MEANS AND VARIANCES, V.P.I. SCALES
OF HIGH, MIDDLE, AND YOUNG AGE ENGINEERING GROUPS

V.P.I. Scales	HIGH AGE (N=18)		MIDDLE AGE (N=21)		YOUNG AGE (N=35)	
	Mean	Variance	Mean	Variance	Mean	Variance
Realistic	7.28	12.20	7.24	11.80	5.34	9.99
Intellectual	7.56	11.58	6.19	11.87	6.00	14.69
Social	1.56	5.14	3.71	16.68	2.69	9.07
Conventional	2.50	7.25	2.62	4.71	2.57	5.16
Enterprising	3.50	12.81	3.86	9.74	4.11	9.30
Artistic	3.22	10.28	4.05	14.43	3.91	15.79

TABLE 16

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF HIGH, MIDDLE, AND YOUNG AGE ENGINEERING GROUPS

Wilks' Lambda = 0.80
F = 1.27
df = 12/132
p = 0.24

A one-way ANOVA was also performed on the same data. The results (in Table 17) indicate an almost significant difference in the Realistic scale ($F=2.93$, $df=2/71$, $p<0.06$). The other five scales show no significant difference.

Figure 6 presents the V.P.I. profiles of the three groups. All three groups show marked elevations in Realistic and Intellectual scales, lesser elevations in Social and Conventional scales. It is interesting to note that there is a tendency that the higher the age, the higher are the scores in the Realistic and Intellectual scales whereas in the Enterprising scale, the opposite is true - the higher the age, the lower is the score.

It appears, therefore, that there is no significant difference in personality patterns among the high, middle and young age engineering groups.

Hypothesis 7

There are no significant differences in mean raw scores for engineers who have considered change of occupation and those who have not.

The means, variances, and multivariate analysis of variance are presented in Tables 18 and 19 respectively.

The null hypothesis was rejected. There was a significant difference between the engineers who have considered change of occupation and those who have not ($F=3.18$, $df=6/67$, $p<0.01$). A Chi-square analysis (Table 20) also confirmed there was a significant difference between the two groups. Of 18 engineers who have considered change of occupation, 14 have personality "types" inconsistent with the environ-

TABLE 17

ONE-WAY ANOVA
OF HIGH, MIDDLE, AND YOUNG AGE ENGINEERING GROUPS

V.P.I. Scale	Source	SS	MS++	F	P
Realistic	Between Group	67.56	33.78	2.93	0.0596
	Within Group	817.31	11.51		
Intellectual	Between Group	30.48	15.24	1.11	0.3341
	Within Group	971.68	13.69		
Social	Between Group	45.19	22.59	2.11	0.1288
	Within Group	760.27	10.71		
Conventional	Between Group	0.14	0.07	0.01	0.9881
	Within Group	410.02	5.77		
Enterprising	Between Group	4.52	2.26	0.21	0.8103
	Within Group	760.61	10.71		
Artistic	Between Group	7.73	3.87	0.26	0.7689
	Within Group	1040.81	14.66		

++df=2/71

FIGURE 6

V. P. I. PROFILES OF
HIGH, MIDDLE & YOUNG AGE ENGINEERING GROUPS

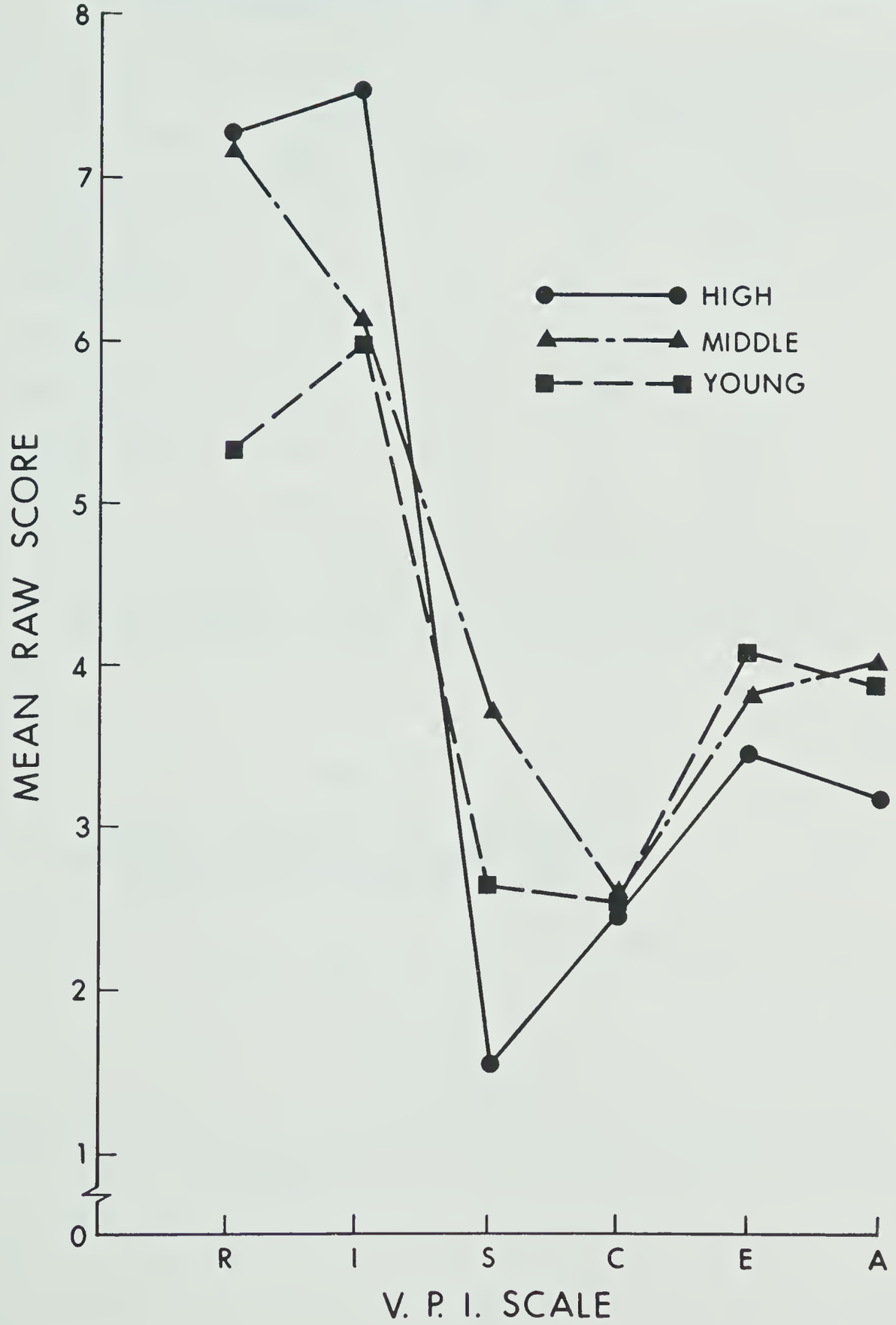


TABLE 18

MEANS AND VARIANCES, V.P.I. SCALES
FOR ENGINEERS WHO HAVE CONSIDERED CHANGE OF
OCCUPATION AND THOSE WHO HAVE NOT

V.P.I. Scales	$\triangle$ (N=18)		$\neq\triangle$ (N=56)	
	Mean	Variance	Mean	Variance
Realistic	6.78	13.17	6.21	11.49
Intellectual	7.78	11.95	6.00	13.27
Social	4.89	18.32	2.00	6.46
Conventional	2.28	3.64	2.66	6.12
Enterprising	4.78	8.39	3.61	10.63
Artistic	4.61	18.24	3.52	12.57

$\triangle$ = Engineers who have considered change of occupation

$\neq\triangle$ = Engineers who have not considered change of occupation

TABLE 19

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF ENGINEERS WHO HAVE CONSIDERED CHANGE OF
OCCUPATION AND THOSE WHO HAVE NOT

Wilks' Lambda = 0.78

F = 3.18

df = 6/67

p = 0.00839**

** $p<0.01$

TABLE 20

CHI-SQUARE ANALYSIS

Predicted Type (Intellectual)	$\triangle$	$\neq \triangle$	X^2
consistent	4	34	8.08**
not consistent	14	22	

$\triangle$ = Engineers who have considered change of occupation
$\neq \triangle$ = Engineers who have not considered change of occupation
**$p < 0.01$

TABLE 21

SUMMARY OF THE MULTIPLE COMPARISONS
BETWEEN ENGINEERS WHO HAVE CONSIDERED CHANGE
OF OCCUPATION AND THOSE WHO HAVE NOT++

V.P.I Scales	Mean Difference	Confidence Interval
Realistic	0.56	-3.036 to 4.163
Intellectual	1.78	-1.979 to 5.535
Social	2.89	-0.302 to 6.079
Conventional	-0.38	-2.834 to 2.068
Enterprising	1.17	-2.144 to 4.485
Artistic	1.09	-2.804 to 4.991

++$\alpha = 0.05$

ment (occupation). But the 95 percent simultaneous confidence intervals test (in Table 21) after significant F reveals no significant differences for the six scales in pairwise comparisons.

A one-way ANOVA was also performed on the same data for further analysis. The results (in Table 22) indicate a significant difference in the Social scale ($F=11.83$, $df=1/72$, $p<0.001$) while the other five scales are not significantly different.

Figure 7 presents the V.P.I. profiles of the two groups. Both groups show marked elevations on the Realistic and Intellectual scales, and lesser elevations on the Enterprising and Artistic scales. It is interesting to note that those who have not considered change of occupation have depression in the Social scale, which is typical among engineers, whereas for those who have considered change of occupation, there is a marked elevation in the Social scale.

In sum, it appears that the engineers who have considered change of occupation differ significantly in personality patterns from those who have not. They have a comparatively higher mean raw score in the Social scale.

Hypothesis 8

There are no significant differences in mean raw scores for Chemical, Civil, and Mechanical Engineers.

The means, variances, and multivariate analysis of variance are presented in Tables 23 and 24 respectively.

The results tend to support the null hypothesis. No significant difference was found among the three groups.

Figure 8 presents the V.P.I. profiles of the three groups. It is

TABLE 22

ONE-WAY ANOVA
OF ENGINEERS WHO HAVE CONSIDERED CHANGE
OF OCCUPATION AND THOSE WHO HAVE NOT

V.P.I. Scale	Source	SS	MS[++]	F	P
Realistic	Between Group	4.32	4.32	0.35	0.5539
	Within Group	880.54	12.23		
Intellectual	Between Group	43.05	43.05	3.23	0.0764
	Within Group	959.11	13.32		
Social	Between Group	113.68	113.68	11.83	0.0009***
	Within Group	691.78	9.61		
Conventional	Between Group	2.00	2.00	0.35	0.5547
	Within Group	408.17	5.67		
Enterprising	Between Group	18.67	18.67	1.80	0.1839
	Within Group	746.47	10.37		
Artistic	Between Group	16.28	16.28	1.14	0.2902
	Within Group	1032.26	14.34		

++ df=1/72

***$p \leq 0.001$

FIGURE 7

V. P. I. PROFILES OF THOSE WHO HAVE CONSIDERED CHANGE OF OCCUPATION & THOSE WHO HAVE NOT

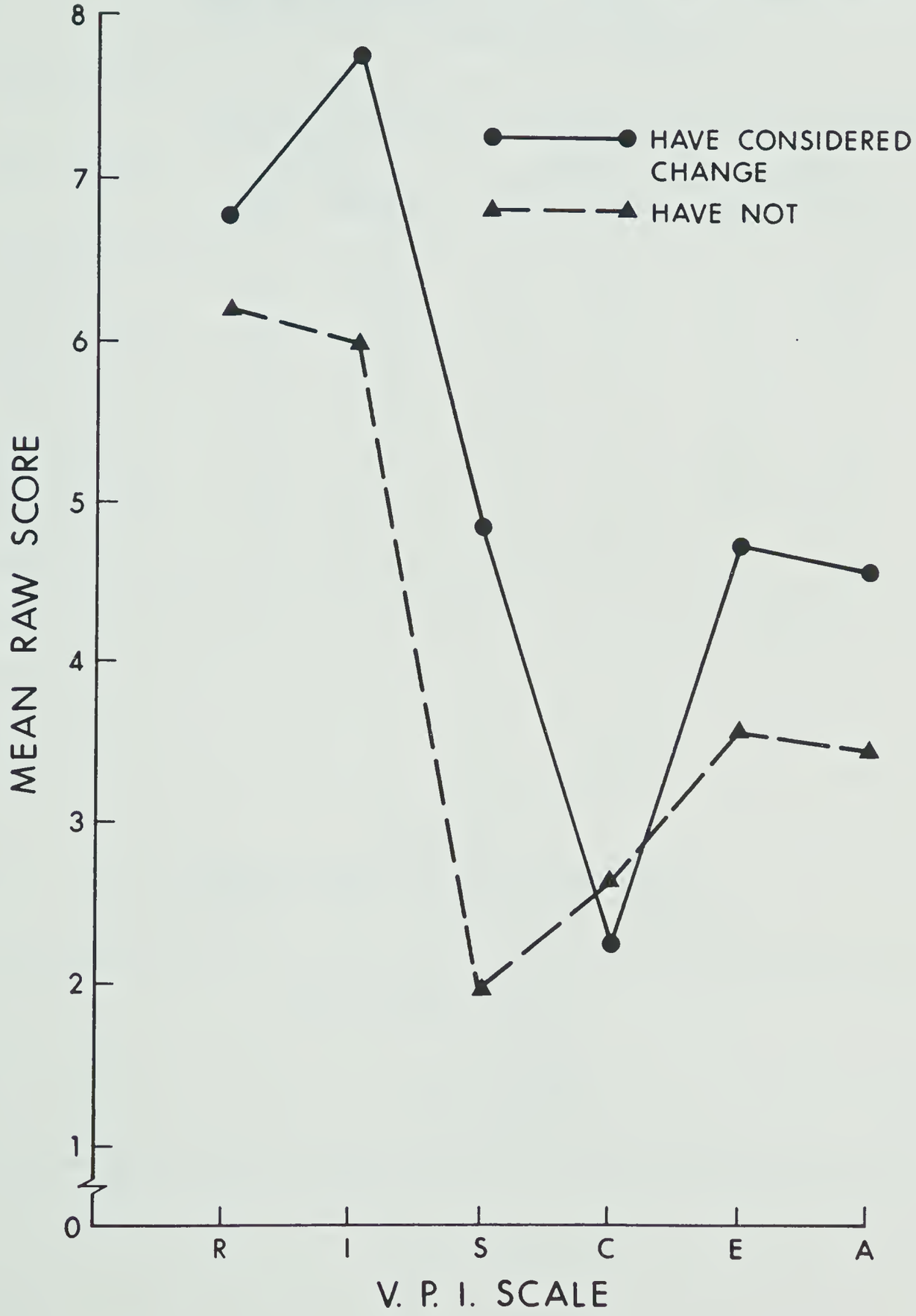


TABLE 23

MEANS AND VARIANCES, V.P.I. SCALES
OF CHEMICAL, CIVIL, AND MECHANICAL ENGINEERS

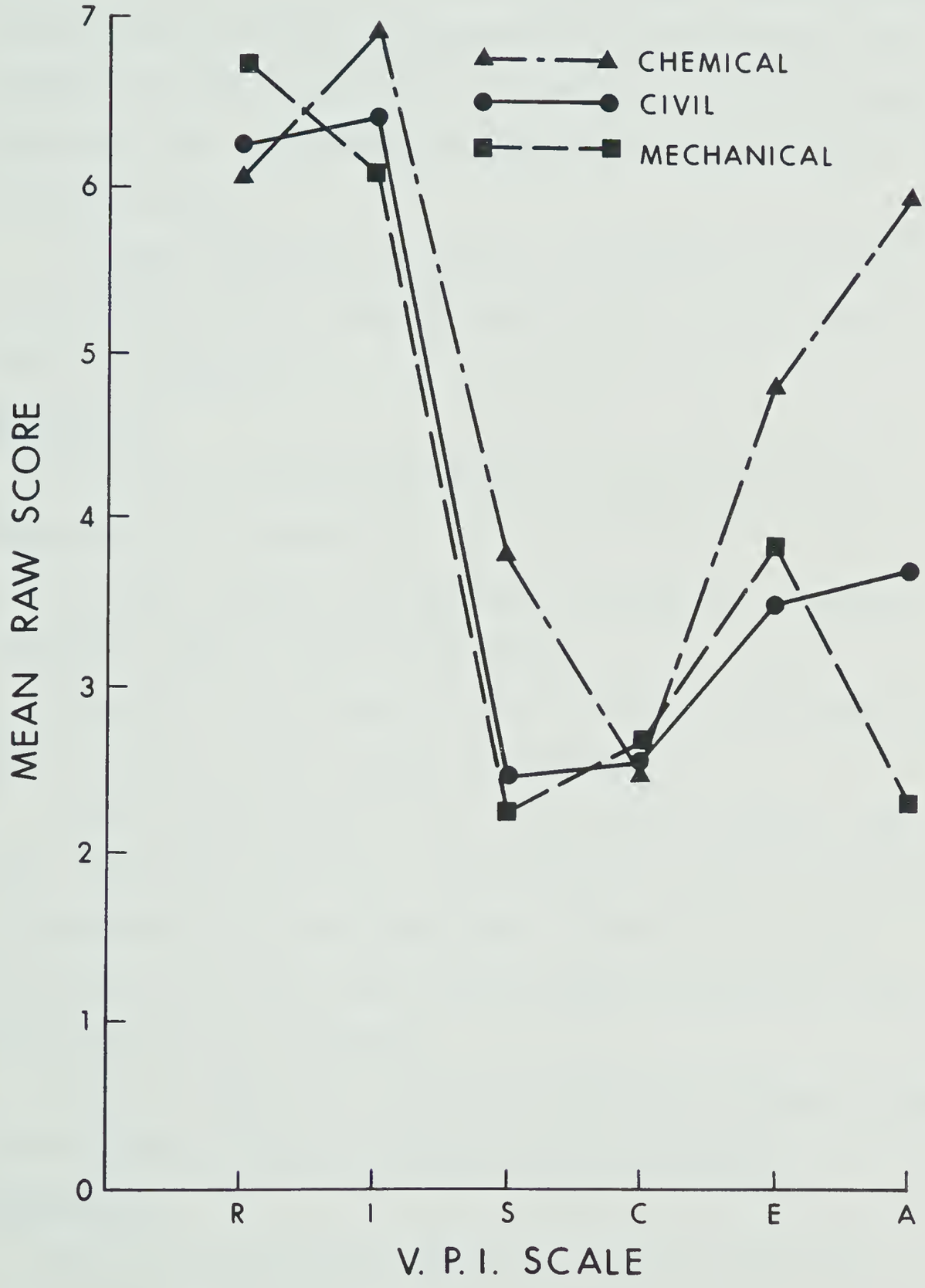
V.P.I. Scales	CHEMICAL ENGINEERS (N=16)		CIVIL ENGINEERS (N=36)		MECHANICAL ENGINEERS (N=22)	
	Mean	Variance	Mean	Variance	Mean	Variance
Realistic	6.06	8.06	6.25	12.97	6.73	12.93
Intellectual	6.94	18.31	6.42	13.97	6.09	9.08
Social	3.81	10.90	2.47	11.25	2.27	9.11
Conventional	2.50	4.13	2.53	5.64	2.68	6.40
Enterprising	4.81	10.90	3.50	9.53	3.86	10.39
Artistic	5.94	19.06	3.72	15.03	2.32	3.67

TABLE 24

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF CHEMICAL, CIVIL, AND MECHANICAL ENGINEERS

Wilks' Lambda = 0.84
F = 1.02
df = 12/132
p = 0.44

FIGURE 8
V. P. I. PROFILES OF
CHEMICAL, CIVIL & MECHANICAL ENGINEERS



noted that with the exception of the Artistic scale, the overall shapes of the three curves are quite similar. All three groups show marked elevations on the Realistic and Intellectual scales, lesser elevations on the Enterprising scale, and depression on the Conventional scale. A marked elevation is also noted in the Artistic scale of the Chemical Engineering group but a pronounced depression for the Mechanical Engineering group.

It appears, therefore, that there is no significant difference in personality patterns among the Chemical, Civil, and Mechanical Engineering groups.

Hypothesis 9

There are no significant differences in mean raw scores for Chemical and Civil Engineers.

The means, variances, and multivariate analysis of variance are presented in Tables 23 and 25 respectively.

The results tend to support the null hypothesis . No significant mean difference was found between the two groups.

Figure 9 presents the V.P.I. profiles of the two groups. Both groups show marked elevations in the Realistic and Intellectual scales but depression in the Conventional scale. There is also a marked elevation in the Artistic scale for the Chemical Engineers but a depression for the Civil Engineers.

In sum, it appears that there is no significant difference in personality patterns between the Chemical and Civil Engineers.

Hypothesis 10

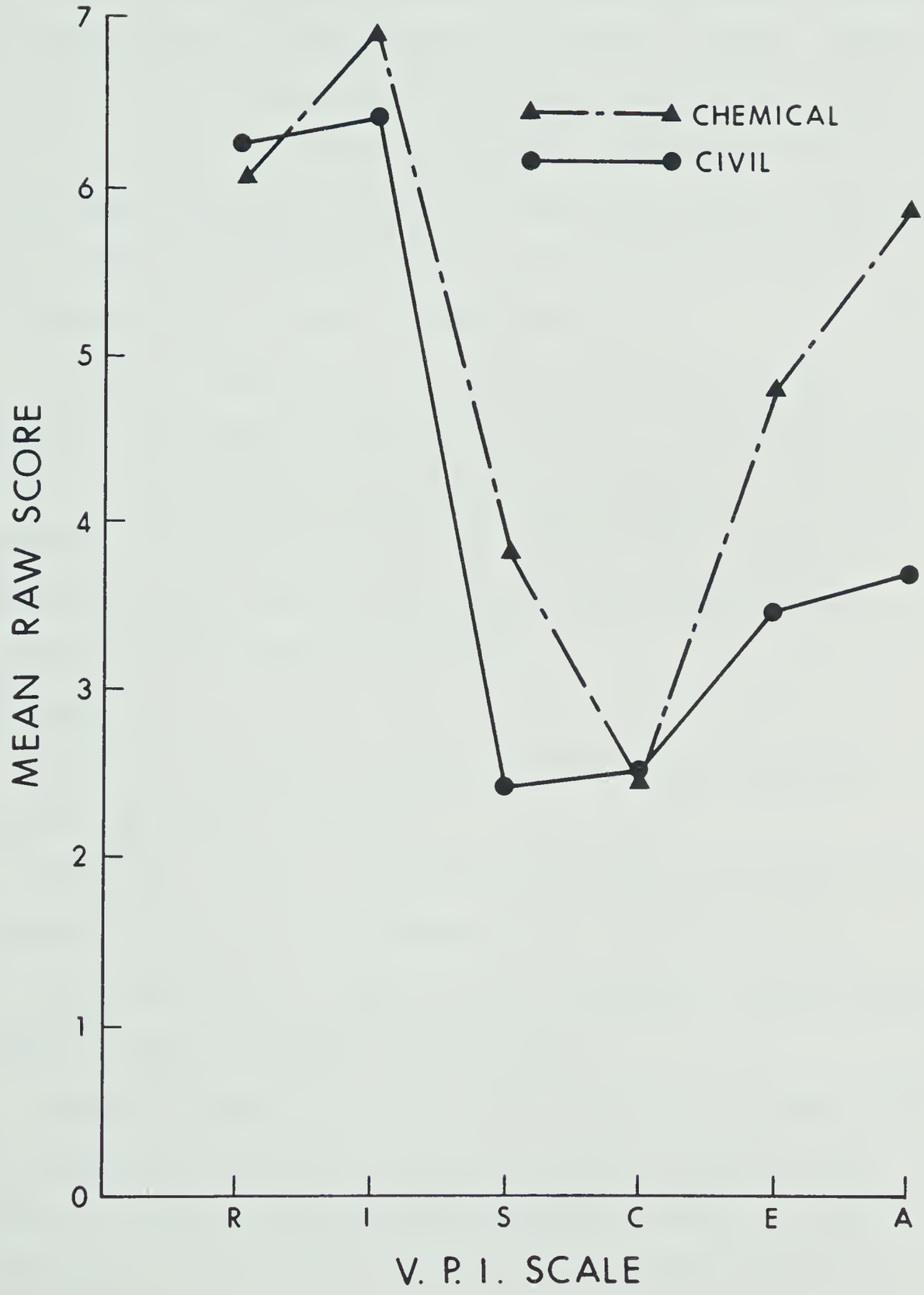
There are no significant differences in mean raw scores for Chemical and Mechanical Engineers.

TABLE 25

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF CHEMICAL AND CIVIL ENGINEERS

Wilks' Lambda	= 0.89
F	= 0.90
df	= 6/45
p	= 0.51

FIGURE 9
V. P. I. PROFILES OF
CHEMICAL & CIVIL ENGINEERS



The means, variances, and multivariate analysis of variance are presented in Tables 23 and 26 respectively.

The null hypothesis was rejected. A significant mean difference was found between the two groups ($F=2.48$, $df=2/31$, $p<0.05$). However, no significant difference was found between the two groups on each of the six variables in pairwise comparison with the 95 percent simultaneous confidence intervals test (Table 27) with the exception of the last scale (Artistic) which is very close to significant difference at the 0.05 level of significance.

Figure 10 presents the V.P.I. profiles of the two groups. Both groups show marked elevations in the Realistic and Intellectual scales, lesser elevation in the Enterprising scale and a pronounced depression in the Conventional scale. There is also a marked elevation on the Artistic scale for the Chemical Engineers but a depression for the Mechanical Engineers.

Hypothesis 11

There are no significant differences in mean raw scores for Civil and Mechanical Engineers.

The means, variances, and multivariate analysis of variance are presented in Tables 23 and 28 respectively.

The results tend to support the null hypothesis. No significant difference was found between the two groups.

Figure 11 presents the V.P.I. profiles of the two groups. With the exception of the Artistic scale, the overall shapes are very similar. Both groups show marked elevations on the Realistic and Intellectual scales, lesser elevation on the Enterprising scale,

TABLE 26

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF CHEMICAL AND MECHANICAL ENGINEERS

Wilks' Lambda	= 0.68
F	= 2.48
df	= 2/31
p	= 0.045*

*p<0.05

TABLE 27

SUMMARY OF THE MULTIPLE COMPARISONS
BETWEEN CHEMICAL AND MECHANICAL ENGINEERS*

V.P.I. Scales	Mean Difference	Confidence Interval
Realistic	-0.66	-5.232 to 3.903
Intellectual	0.85	-4.140 to 5.834
Social	1.54	-2.810 to 5.889
Conventional	-0.18	-3.412 to 3.049
Enterprising	0.95	-3.561 to 5.459
Artistic	3.62	-0.793 to 8.032

*α=0.05

FIGURE 10
V. P. I. PROFILES OF
CHEMICAL & MECHANICAL ENGINEERS

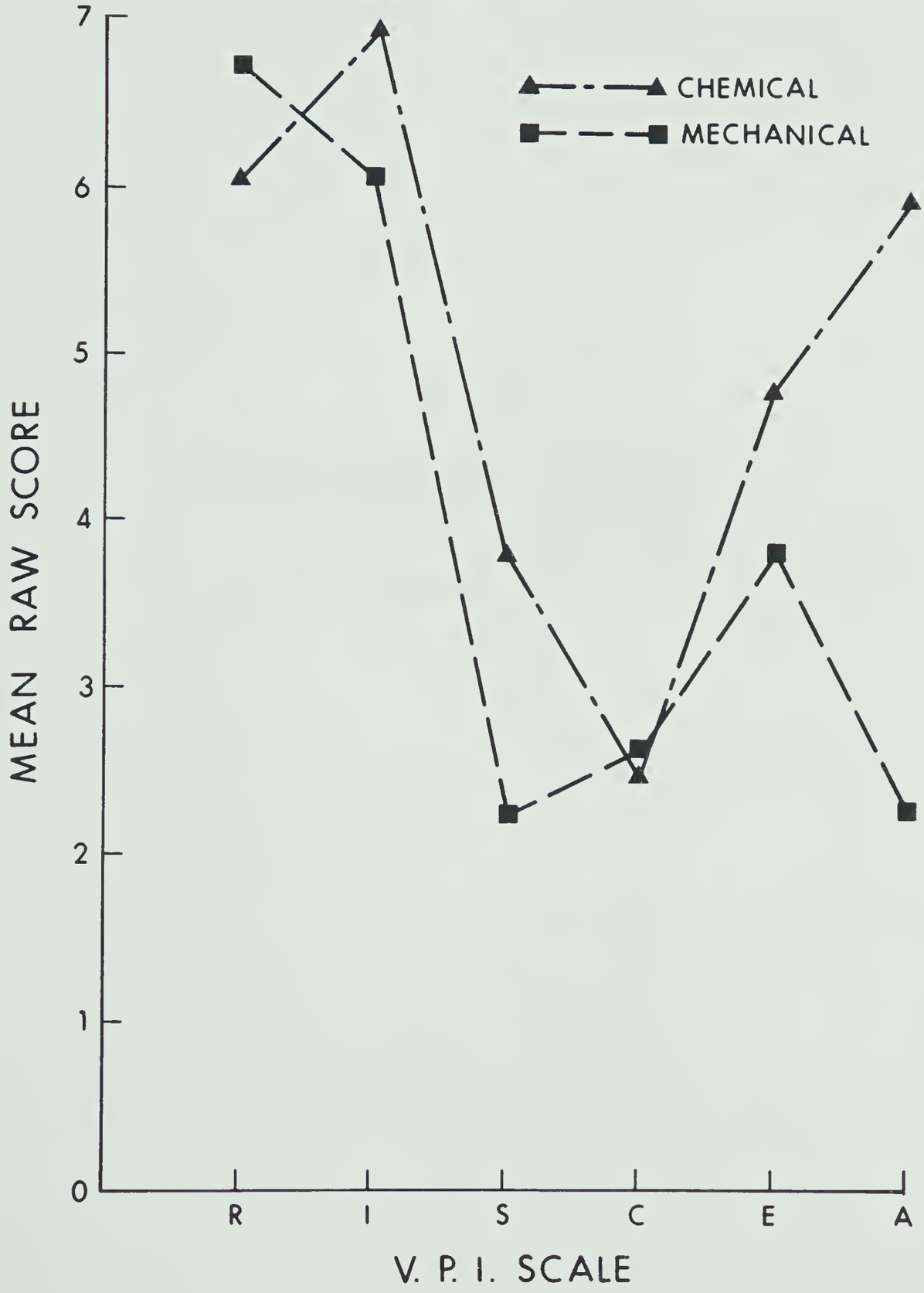
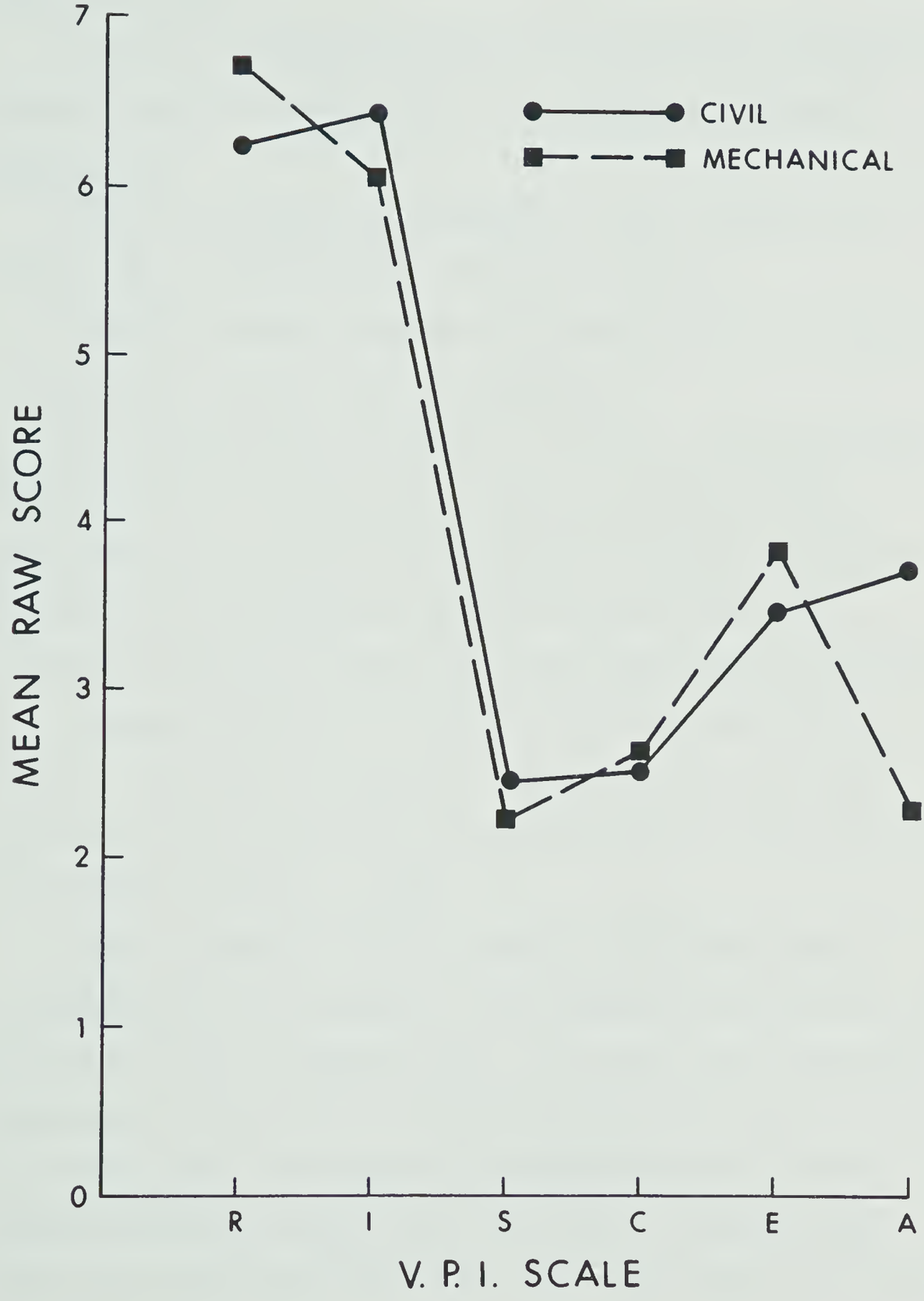


TABLE 28

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF CIVIL AND MECHANICAL ENGINEERS

Wilks' Lambda	0.93
F	0.61
df	6/51
p	0.72

FIGURE 11
V.P.I. PROFILES OF
CIVIL & MECHANICAL ENGINEERS



and depressions on the Social and Conventional scales. There is also a pronounced depression on the Artistic scale for the Mechanical Engineering group.

To sum up, it appears that there is no significant difference in personality patterns between the Civil and Mechanical Engineers.

Hypothesis 12

There are no significant differences in mean raw scores for Chemical, Civil, and Mechanical Engineering Students.

The means, variances, and the multivariate analysis of variance are presented in Tables 29 and 30 respectively.

The null hypothesis was rejected. There was a significant mean difference among the three groups ($F=2.02$, $df=12/240$, $p<0.05$). However there was no significant difference in pairwise comparison for each of the six variables with the 95 percent simultaneous confidence intervals test (Table 31) at the 0.05 level of significance.

A one-way ANOVA was also applied to the same data for further analysis. The results presented in Table 32 indicate significant differences in the Conventional and Artistic scales ($F=3.12$, $df=2/125$, $p<0.05$; $F=3.67$, $df=2/125$, $p<0.05$).

Figure 12 presents the V.P.I. profiles of the three groups. It is noted that with the exception of the Conventional and Artistic scales, the overall shapes are rather similar. The three groups show marked elevations on the Realistic and Intellectual scales, lesser on the Enterprising scale, and depression on the Social scale. For the Chemical Engineering Student group, they have a relatively higher score on the Conventional scale but a lower one on the Artistic scale,

TABLE 29

MEANS AND VARIANCES, V.P.I. SCALES
OF CHEMICAL, CIVIL, AND MECHANICAL ENGINEERING STUDENTS

V.P.I. Scales	CHEMICAL (N=36)		CIVIL (N=44)		MECHANICAL (N=48)	
	Mean	Variance	Mean	Variance	Mean	Variance
Realistic	4.49	12.66	3.96	5.95	5.23	9.80
Intellectual	6.14	14.56	4.66	12.09	5.50	12.79
Social	1.61	4.57	1.59	6.29	1.96	7.25
Conventional	3.08	9.35	1.84	3.18	1.92	5.74
Enterprising	4.03	12.08	3.86	8.85	3.23	8.14
Artistic	1.92	5.97	2.86	12.62	3.90	12.89

CHEMICAL = Chemical Engineering Students
CIVIL = Civil Engineering Students
MECHANICAL = Mechanical Engineering Students

TABLE 30

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF CHEMICAL, CIVIL, AND MECHANICAL ENGINEERING STUDENTS

Wilks' Lambda = 0.82
F = 2.02
df = 12/240
p = 0.02*

*$p < 0.05$

TABLE 31

SUMMARY OF THE MULTIPLE COMPARISONS
AMONG CHEMICAL, CIVIL, AND MECHANICAL ENGINEERING STUDENTS*

V.P.I. Scales	Groups	Mean Difference	Confidence Interval
Realistic	1-2	0.74	-2.175 to 3.655
	1-3	-0.53	-3.394 to 2.325
	2-3	-1.27	-3.982 to 1.432
Intellectual	1-2	1.48	-1.976 to 4.936
	1-3	0.64	-2.752 to 4.029
	2-3	-0.84	-4.050 to 2.369
Social	1-2	0.02	-2.355 to 2.396
	1-3	-0.35	-2.678 to 1.983
	2-3	-0.37	-2.574 to 1.839
Conventional	1-2	1.24	-1.077 to 3.562
	1-3	1.17	-1.109 to 3.442
	2-3	-0.08	-2.230 to 2.078
Enterprising	1-2	0.16	-2.783 to 3.111
	1-3	0.80	-2.093 to 3.690
	2-3	0.63	-2.103 to 3.372
Artistic	1-2	-0.95	-4.098 to 2.204
	1-3	-1.98	-5.070 to 1.112
	2-3	-1.03	-3.958 to 1.894

*α = 0.05

1 = Chemical Engineering Students

2 = Civil Engineering Students

3 = Mechanical Engineering Students

TABLE 32

ONE-WAY ANOVA
OF CHEMICAL, CIVIL, AND MECHANICAL ENGINEERING STUDENTS

V.P.I. Scale	Source	SS	MS++	F	P
Realistic	Between Group	37.44	18.72	1.97	0.1438
	Within Group	1188.03	9.50		
Intellectual	Between Group	44.28	22.14	1.66	0.1949
	Within Group	1670.19	13.36		
Social	Between Group	3.86	1.93	0.31	0.7371
	Within Group	789.11	6.31		
Conventional	Between Group	37.57	18.79	3.12	0.0475*
	Within Group	752.30	6.02		
Enterprising	Between Group	15.59	7.79	0.80	0.4507
	Within Group	1214.63	9.72		
Artistic	Between Group	81.56	40.78	3.67	0.0282*
	Within Group	1388.41	11.11		

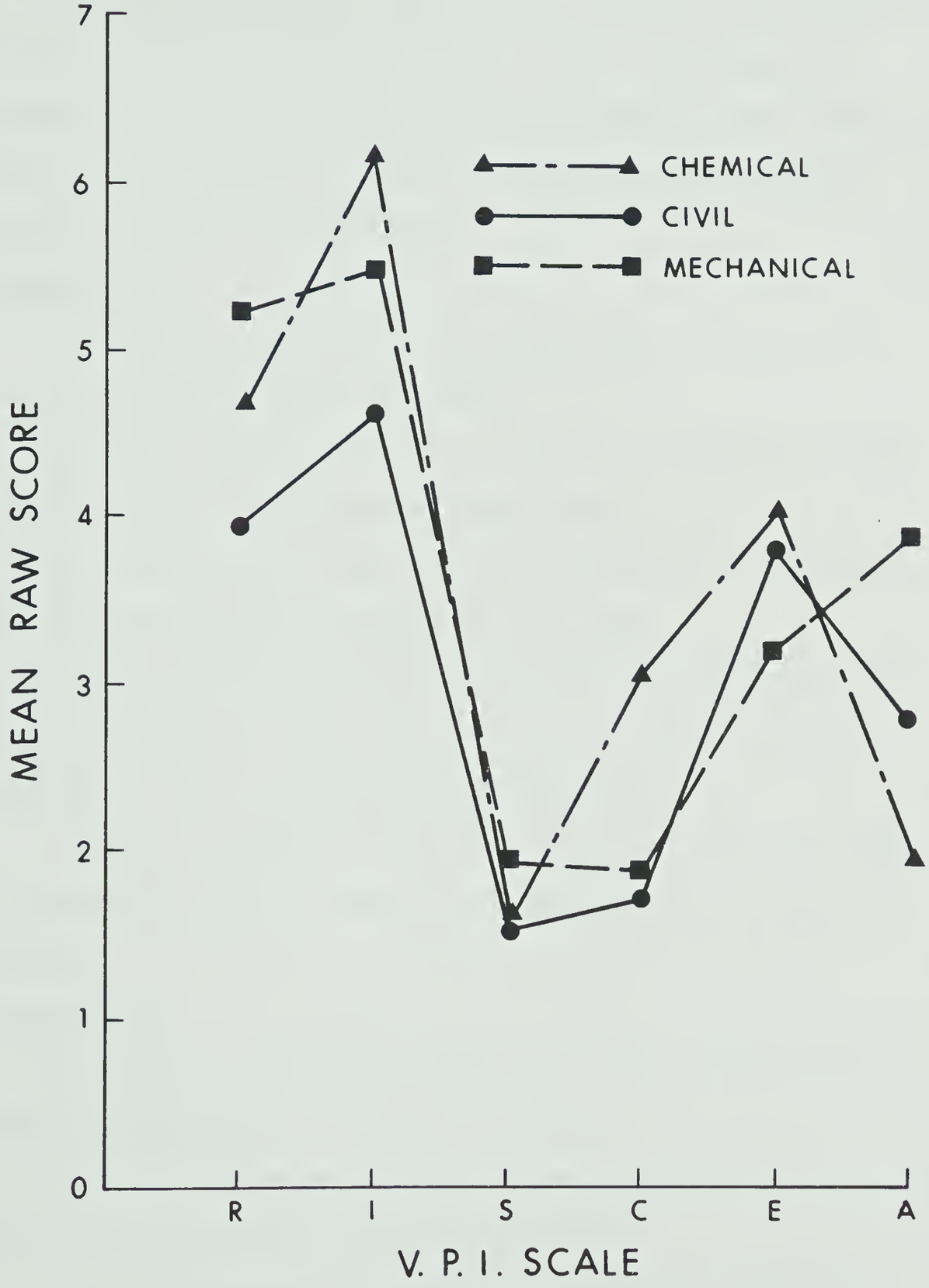
++df = 2/125

*$p \leq 0.05$

FIGURE 12

V. P. I. PROFILES OF

CHEMICAL, CIVIL & MECHANICAL ENGINEERING STUDENTS



whereas the Mechanical Engineering Student group show a higher score on the Artistic scale but a lower one on the Conventional scale.

It appears, therefore, that there are significant differences in personality patterns among the Chemical, Civil, and Mechanical Engineering students with the Chemical Engineering students higher on Conventional but lower in Artistic, and the Mechanical higher in Artistic but lower in Conventional.

Hypothesis 13

There are no significant differences in mean raw scores for Chemical and Civil Engineering Students.

The means, variances, and the multivariate analysis of variance are presented in Tables 29 and 33 respectively.

The results tend to support the null hypothesis. No significant mean difference was found between the two groups.

Figure 13 presents the V.P.I. profiles of the two groups. Both groups are similar in shapes and have the consistent personality patterns of I.R.E. as predicted by Holland (1977).

It appears, therefore, that there is no significant difference in personality patterns between the Chemical and Civil Engineering Students.

Hypothesis 14

There are no significant differences in mean raw scores for Chemical and Mechanical Engineering Students.

The means, variances, and the multivariate analysis of variance are presented in Tables 29 and 34 respectively.

The null hypothesis was rejected. There was a significant difference between the two groups ($F=2.78$, $df=6/77$, $p<0.05$). However,

TABLE 33

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF CHEMICAL AND CIVIL ENGINEERING STUDENTS

Wilks' Lambda	0.86
F	2.00
df	6/73
p	0.08

TABLE 34

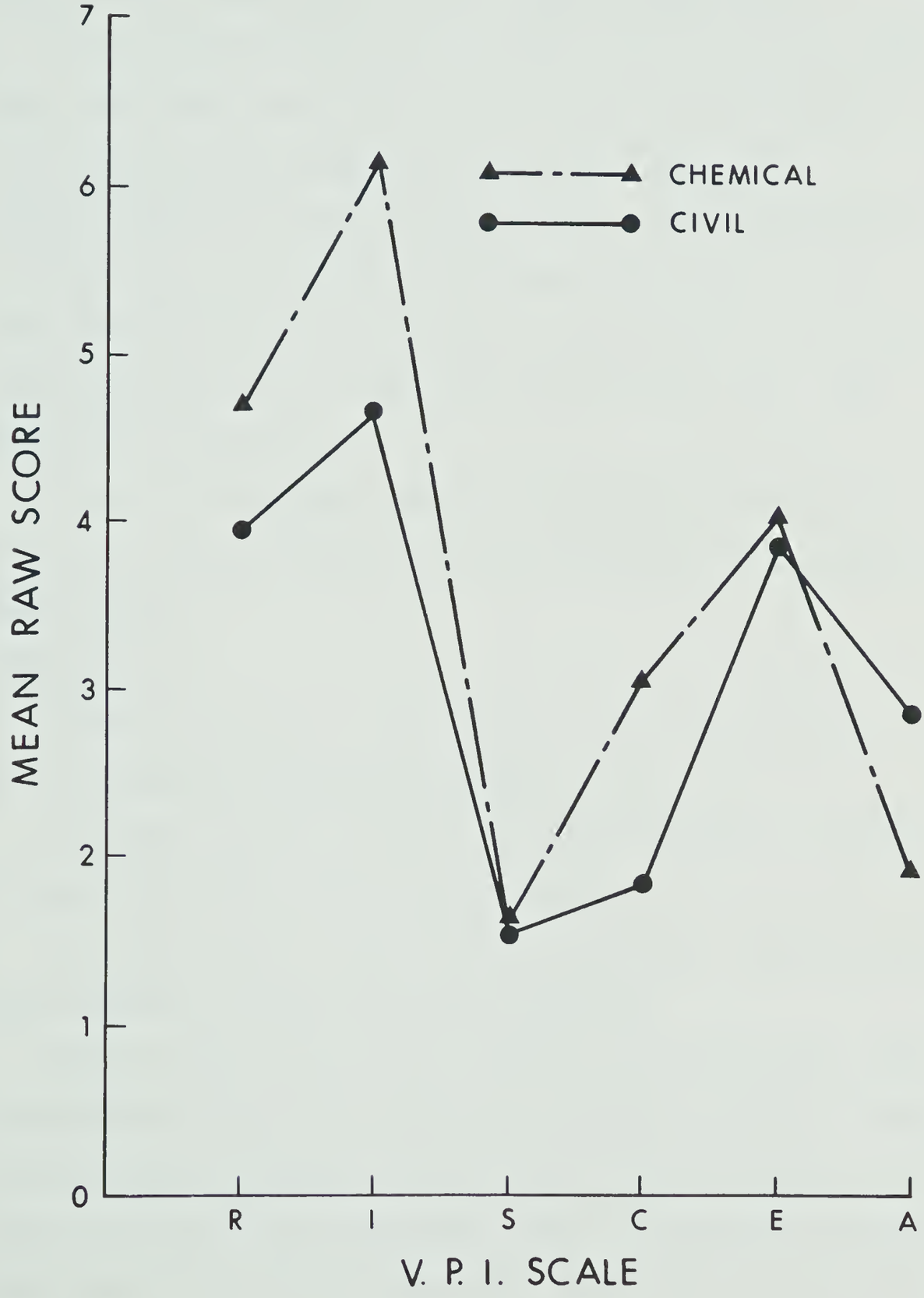
ONE-WAY MANOVA OF 6 V.P.I VARIABLES
OF CHEMICAL AND MECHANICAL ENGINEERING STUDENTS

Wilks' Lambda	0.82
F	2.78
df	6/77
p	0.01691*

*$p \leq 0.05$

FIGURE 13

V. P. I. PROFILES OF
CHEMICAL & CIVIL ENGINEERING STUDENTS



there was no significant difference in pairwise comparison for each of the six variables with the 95 percent simultaneous confidence intervals test (Table 35) at the 0.05 level of significance.

Figure 14 presents the V.P.I. profiles of the two groups. Both groups show marked elevations on the Realistic and Intellectual scales but pronounced depression on the Social scale. The Chemical Engineering Student group also shows a marked elevation on the Enterprising scale, lesser on the Conventional scale, and a depression on the Artistic scale whereas the Mechanical Engineering Student group displays a higher score on the Artistic but a lower score on the Conventional.

In sum, it appears that there is a significant difference in personality patterns between the Chemical and Mechanical Engineering Student groups.

Hypothesis 15

There are no significant differences in mean raw scores for Civil and Mechanical Engineering Students.

The means, variances, and the multivariate analysis of variance are presented in Tables 29 and 36 respectively.

The results tend to support the null hypothesis. No significant mean difference was found between the two groups.

Figure 15 presents the V.P.I. profiles of the two groups. With the exception of the Artistic scale, both groups are similar in shape. They show marked elevations on the Realistic and Intellectual scales, lesser on the Social and Conventional scales. The Mechanical Engineering Student group has a comparatively higher score on the Artistic scale.

TABLE 35

SUMMARY OF THE MULTIPLE COMPARISONS
BETWEEN CHEMICAL AND MECHANICAL ENGINEERING STUDENTS*

V.P.I. Scales	Mean Difference	Confidence Interval
Realistic	-0.53	-3.326 to 2.257
Intellectual	0.64	-2.456 to 3.734
Social	-0.35	-2.424 to 1.729
Conventional	1.17	-1.103 to 3.437
Enterprising	0.80	-1.837 to 3.434
Artistic	-1.98	-4.627 to 0.669

*α=0.05

TABLE 36

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF CIVIL AND MECHANICAL ENGINEERING STUDENTS

Wilks' Lambda = 0.92
F = 1.31
df = 6/85
p = 0.26

FIGURE 14

V. P. I. PROFILES OF
CHEMICAL & MECHANICAL ENGINEERING STUDENTS

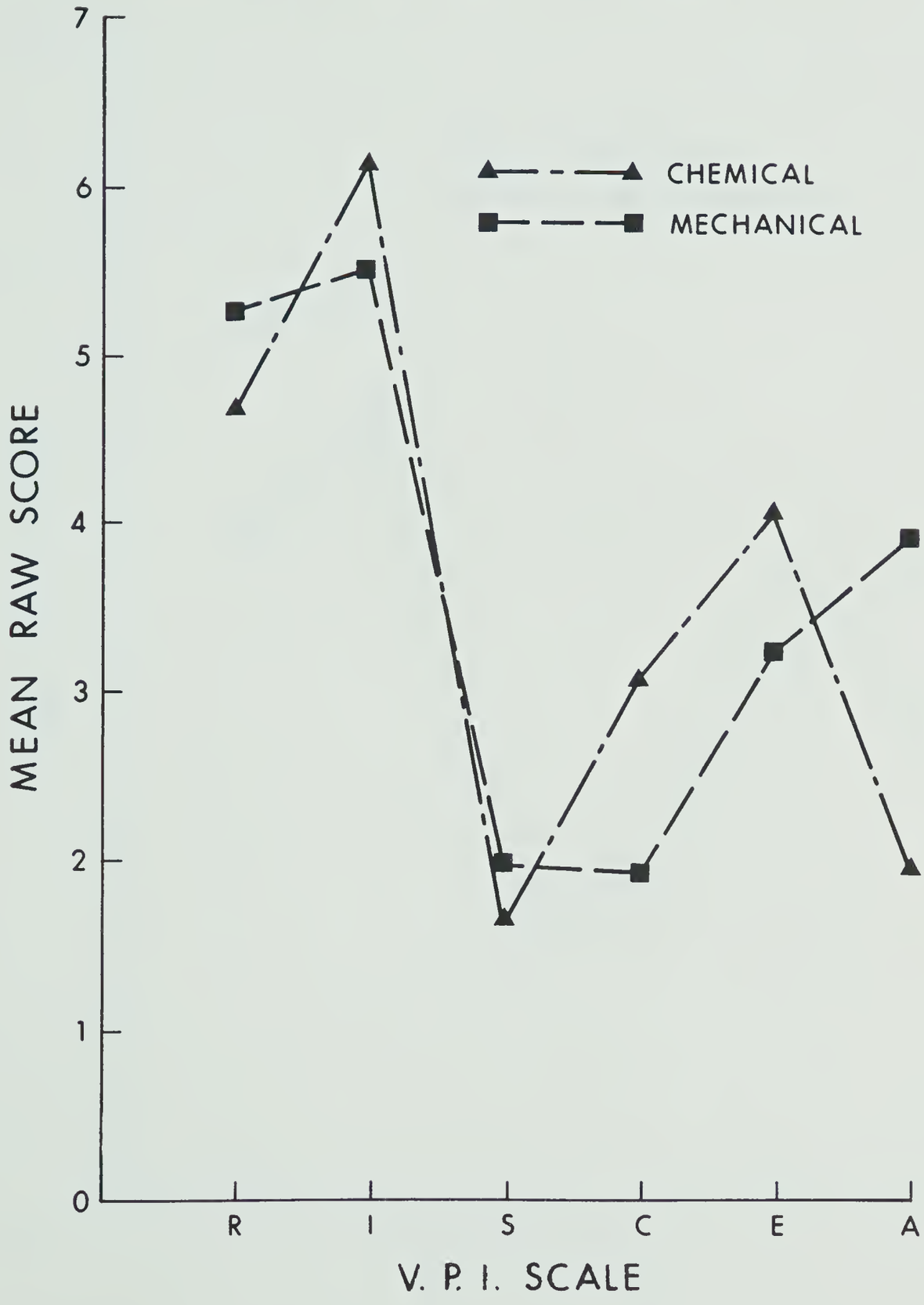
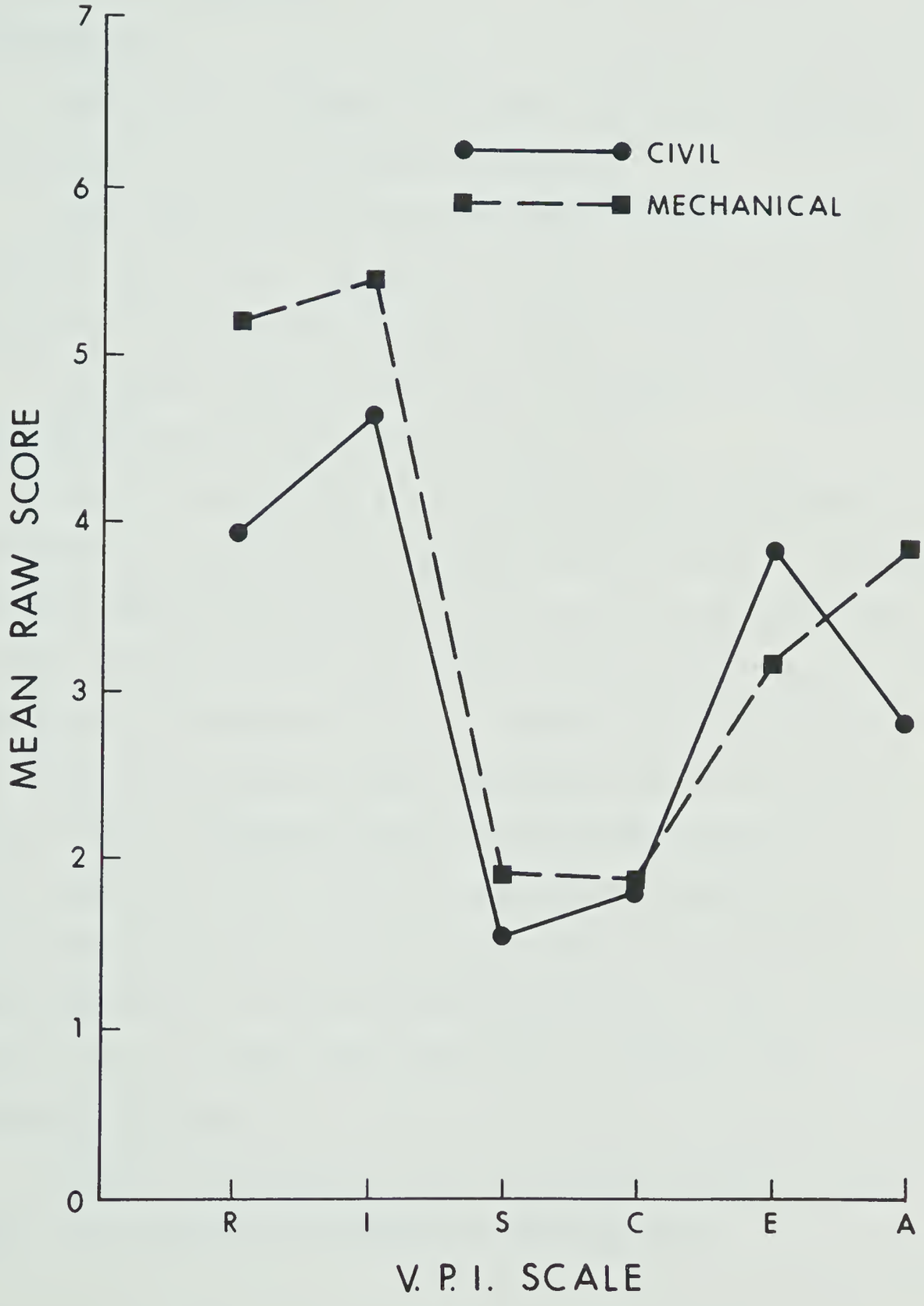


FIGURE 15

V. P. I. PROFILES OF
CIVIL & MECHANICAL ENGINEERING STUDENTS



It appears, therefore, that the Civil Engineering students do not differ significantly from the Mechanical Engineering students in personality patterns.

Hypothesis 16

There are no significant differences in mean raw scores for Development, Sales, and Production Engineers.

Since there was only one Basic Research Engineer, he was not included for analysis. The means, variances, and the multivariate analysis of variance are presented in Tables 37 and 38 respectively.

The results tend to support the null hypothesis. No significant mean difference was found among the three groups.

Figure 16 presents the V.P.I. profiles of the three groups. The profile of the Production Engineering group is that of a "typical" engineer showing marked elevation on the Realistic and Intellectual scales, lesser elevation on the Enterprising scale and depressions on the Social and Conventional scales. However, the profile of the Sales Engineering group displays unexpectedly marked elevations on the Realistic and Enterprising scales and pronounced depression on the Conventional scale whereas the Development Engineering group show marked elevations (but with lower scores as compared with the other two groups) on the Intellectual and Realistic scales, lesser on the Artistic and rather flat on the Social, Conventional and Enterprising scales.

Owing to limited sample size, no conclusive statement can be made. The findings are presented for reference only.

TABLE 37

MEANS AND VARIANCES, V.P.I. SCALES
OF DEVELOPMENT, SALES, AND PRODUCTION ENGINEERS

V.P.I. SCALES	DEVELOPMENT ENGINEERS (N=6)		SALES ENGINEERS (N=4)		PRODUCTION ENG. (N=63)	
	Mean	Variance	Mean	Variance	Mean	Variance
Realistic	4.67	9.56	7.75	1.19	6.48	12.47
Intellectual	5.50	12.92	6.75	13.69	6.60	13.03
Social	2.83	2.81	2.50	2.75	2.75	12.22
Conventional	3.00	7.33	1.75	3.19	2.62	5.44
Enterprising	3.00	13.33	6.00	14.00	3.87	9.57
Artistic	3.67	13.56	4.25	20.19	3.81	13.93

TABLE 38

ONE-WAY MANOVA OF 6 V.P.I. VARIABLES
OF DEVELOPMENT, SALES, AND PRODUCTION ENGINEERS

Wilks' Lambda = 0.88

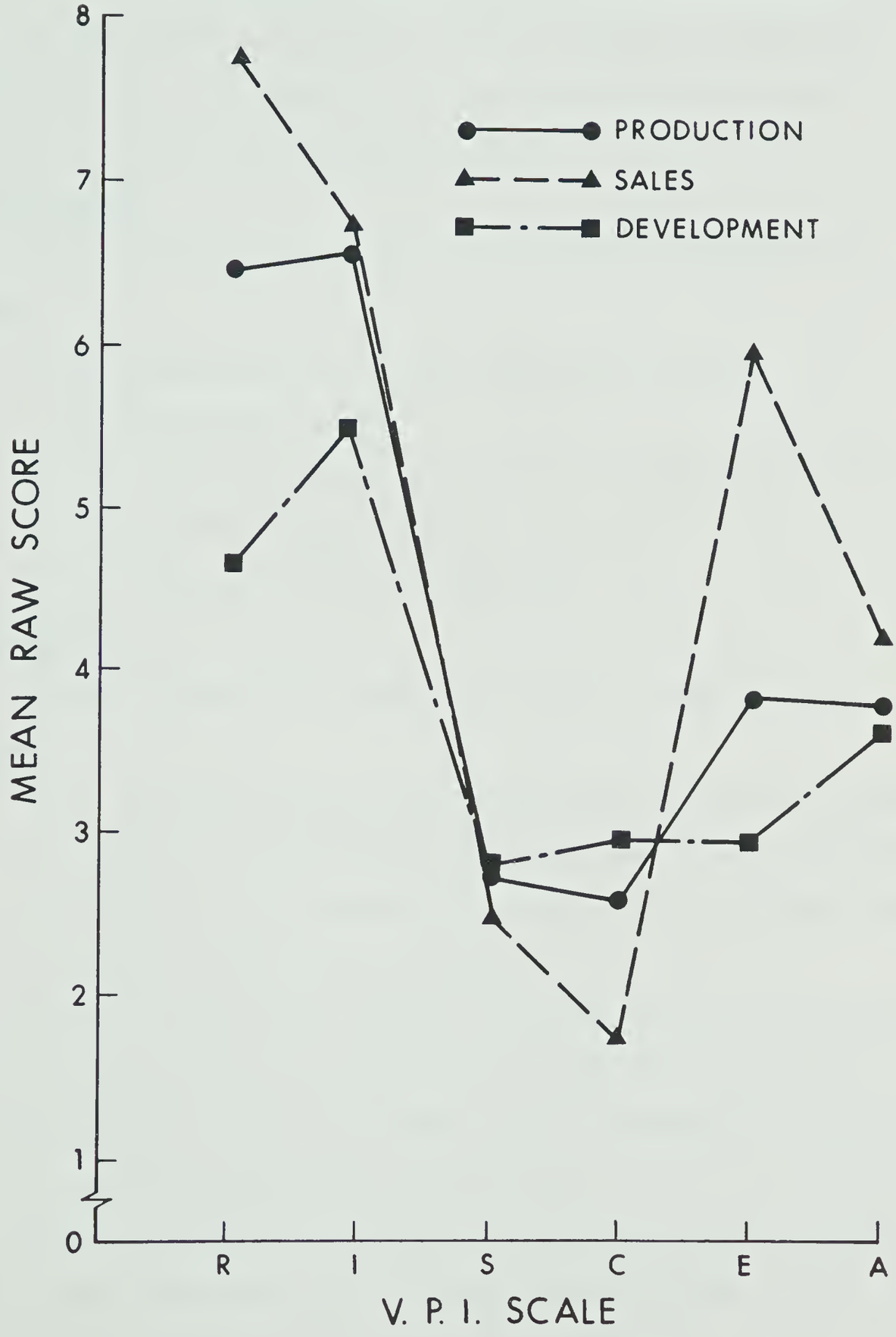
F = 0.71

df = 12/130

p = 0.74

FIGURE 16

V. P. I. PROFILES OF
DEVELOPMENT, PRODUCTION & SALES ENGINEERS



CHAPTER V

DISCUSSION AND CONCLUSIONS

In this chapter, the research findings presented in Chapter IV are discussed in some detail in relation to the questions raised in Chapter I and their implications indicated.

Delimitations

For the purpose of this study, the following delimitations are made:

1. Only companies with Chemical, Civil, or Mechanical Engineering are included.
2. The findings are relevant to Holland's theory as operationalized through the research questions.
3. The sample studied is the population.

Assumptions

For the purpose of this study, the following assumptions are made:

1. It is assumed that the students who have registered in engineering program in different specialties have narrowed their vocational choices to the alternative outlined by the program description offered by University of Alberta.
2. It is assumed that engineers (Chemical, Civil and Mechanical) who are working in a specific job duty have narrowed their choice to that option though with the knowledge of the other options of job duties in their firms.
3. It is assumed that engineers who were not trained at University of Alberta had similar training programs offered at other universities.

4. It is assumed that Holland's classifications hold for this sample.

Discussion

The results are discussed in relation to three areas, namely, (1) personality type and educational/vocational choice, (2) personality patterns of engineering students and engineers and, (3) personality change.

(1) Personality Type and Educational/Vocational Choice The findings lend general support to Holland's theory of vocational choice (Holland, 1973) proposing that individuals tend to choose actual occupational environments consistent with their personality types. In his theory, Holland suggests that people who work in a given occupation should score higher in that occupation (scale) than on any other scales. The results for the V.P.I. show that all the Chemical and Civil Engineers and Engineering students had their highest mean scores on the Intellectual scale (Tables 22 & 29) and the Mechanical Engineers had their highest mean score on the Realistic scale (Table 22), consistent with Holland's predictions (1977). The results of this study are also consistent with the findings of the other investigators on personality types and educational/vocational choice (Osipow, Ashby & Wall, 1967; Kelso, 1969; Lacey, 1971; Gaffey & Walsh, 1974; Gross & Gaier, 1974). However, there is one interesting finding. The Mechanical Engineering students had their highest mean score on the Intellectual scale instead of Realistic scale as predicted by Holland (1977) and the second highest mean score on the Realistic

scale (Table 29). This can be interpreted as they are influenced by the academic environment (university) and they have to 'survive' in the 'system' which places a considerable emphasis on academic achievement.

(2) Personality Patterns of Engineering Students and Engineers

Though significant difference in personality patterns was found between the two groups (Tables 3 & 4), the overall shapes of the two curves are quite similar with the engineering group having a comparatively higher mean raw scores in all six of the scales. Both groups show marked elevations on the Realistic and Intellectual scales, lesser elevation on Enterprising, and a depression on the Social and Conventional scales. These profiles (Figure 1) present them as asocial, masculine, practical, stable, analytical, independent, intellectual, achieving and introverted (Holland, 1973, pp.14, 15). The engineers, significantly higher on the Realistic and Social scales, tend to be more mechanically inclined and practical. They are more tactful and understanding and know how to manipulate others whereas the engineering students are more scientifically inclined, intellectual and idealistic. The results give support to Holland's description of a typical engineer and the findings of other investigators (Goodman, 1942; Norman, 1952; Harrison, Tomblen & Jackson, 1955; Izard, 1960; Yanico, Hardin & McLaughlin, 1978). It is interesting to note that when fourth year engineering students were compared with the engineering group, no significant mean difference was found (Table 12). This tends to support Lacey's findings (1971) of no

significant differences between the working group and the college group.

The present findings of significant difference between Chemical and Mechanical engineers as well as between Chemical and Mechanical engineering students (Tables 26 & 34) support the proposition that "engineers should not be lumped together into a single category" (Dunnette et al., 1964, p.492; Bucher & Strauss, 1961; Izraeli, Krausz & Garber, 1979). The three letter codes for the sample groups on the V.P.I. determined by a rank ordering of the three highest mean scores are as follows: Chemical Engineers IRA, Civil Engineers IRA, Mechanical Engineers RIE, Chemical Engineering Students IRE, Civil Engineering Students IRE, and Mechanical Engineering Students IRA. These codes suggest that the sample groups are clearly similar, yet different. The three letter codes of the Mechanical Engineers, Chemical and Civil Engineering Students are identical with those presented in Holland's Occupations Finder (1977). In general, the Chemical and Civil Engineering Groups tend to be more scientifically inclined and inventive whereas the Mechanical Engineering Group tends to be more mechanically inclined and practical. There was a conflicting finding when the Artistic scores of the Chemical Engineers and Engineering Students were compared. The mean raw score of the Chemical Engineers was much higher than that of the Chemical Engineering Students. This might be due to the high variance of the scores of the Artistic scale of the Chemical Engineering group, resulting in an unexpectedly high mean raw

score.

(3) Personality Change The results of significant difference in personality patterns (Tables 19, 20 & 22) between those who have considered change of occupation and those who have not also support Holland's theory of vocational choice on the aspect of career change and personality change. In terms of career change, Holland has made the prediction explicitly: "In theoretical terms, people leave because of excessive person-environment incongruent, or because of an opportunity to increase their congruity" (Holland & Gottfredson, 1976, p.21). Of 18 engineers who have considered change of occupation, 14 have personality types inconsistent with the environment (occupation). This also lends support to the investigations of Elton (1971), Taylor and Hanson (1972), and Mount and Muchinsky (1978). Elton (1971) found that there was a personality change for males who left engineering. They were different from that found among those who remained in engineering. Taylor and Hanson (1972) found that the Strong Vocational Interest Inventory profiles of transfers from a college of engineering indicated a loss of physical science interest and an increase in social service, business management and sales interests over three years. The present study also found that those engineers who have considered change of occupation had significantly higher mean raw score on the Social scale. They are rather social and persuasive. They value social and religious movement. A further analysis of the data revealed that of 13 who answered the question of preferred job change, 4 wanted to be

teachers (SAE), 3 wanted to be businessmen (ESC) and one wanted to be a cellist (ISR) and other wanted to be a dentist (ISR). An examination of the occupations indicates that most of them are categorized under the Social and Enterprising types according to Holland's Occupations Finder (1977).

The results of significant difference between second year engineering students and engineers (Table 9) and no significant difference between fourth year engineering students and engineers (Table 12) offer support for the postulate that the student body of a particular program would have a personality pattern more consistent with the members of the intended Occupational Environment as the length of time spent in the program increases. These findings would also seem to support the findings of Walsh and Lacey (1969, 1970) and Walsh, Vaudrin, and Hummel (1972).

The results of no significant mean difference (Table 16) among high, middle, and young age engineering groups offer support to the findings of Vaitenas and Wiener (1977). They examined the personality traits of 45 mid-career changers with 66 vocationally stable controls. They were unable to find any differences arising from age alone and so conclude that developmental theory is not adequate to explain mid-career change.

Despite findings of no significant difference, there is a tendency of having higher mean raw scores on the Realistic scale as the engineers grow older (Figure 6). The findings of significant difference between engineers and engineering students (Table 6) where engineers scored significantly higher score on the Realistic

scale also lend support to this. On the other hand, the engineers tend to score lower on the Enterprising scale as they grow older. These two aspects have some important implications for further research.

Implications for Further Research

In terms of further research, the following implications exist:

1. A sample of engineering students and engineers in other specialties such as petroleum engineering, mining engineering, aeronautical engineering, electrical engineering and industrial engineering should be studied to determine whether the findings from this study are general.
2. It would be interesting to include female engineering students and engineers as subjects in replicating this study. Until the hypotheses in this study are tested on women, any generalization to all engineering students and engineers is unjustified. Research by Carlson (1970) has supported Roe's suggestion that a separate vocational development theory may be necessary for women.
3. There is a need for replication in a much larger sample in each of the job duties, namely Basic Research, Applied Research and Development, Production and Process, and Sales and Technical Service of engineers and engineering students in different specialties by using the V.P.I. as the discriminatory instrument.
4. There is also a need for replication in a much larger sample in each of the engineering specialty in examining the tendency of

scoring higher on the Realistic scale, but lower on the Enterprising scale as the engineers grow older.

Implications for Counseling

The findings of this study support the proposition that "engineers should not be lumped together into a single category" (Dunnette et al., 1964, p.492). Engineers do not form a homogenous category because engineering like other professions, is not homogenous. It is rather, as Bucher and Strauss (1961) have suggested, "an amalgamation of segments," characterized by different objectives, activities, values, and interests, "more or less delicately held together under a common name, at a particular period in history" (Bucher & Strauss, p.326). Chemical and Civil Engineers or engineering students are similar in personality patterns but different from Mechanical engineers or engineering students. This has significant implications for counseling. Different types of persons select different types of engineering specialties. The Vocational Preference Inventory seems to be desirable as a brief, screening inventory for providing vocational counselors at University of Alberta useful information in helping male engineering students to decide on the specialty. It also provides helpful information for vocational counselors in counseling engineers who have been considering change of occupation because their personality types are incongruent with the environment.

However, the writer wishes to point out that other factors such as the clients' abilities and expectations, the economy of society in general, societal demand, the current situations in the work force, employment opportunities, and other environmental constraints, though

beyond the scope of this study, should be taken into consideration in the process of vocational counseling. If the vocational counselor is to do a thorough job, he should not be blind to the realities of the social forces swirling through the society in general and the world of work in particular. Instead, he should draw a good balance between the needs of the clients who are the objects of his attention and the needs of the economic system - which are the needs that determine the operations of the world of work.

Conclusions

In conclusion, the findings of this study tend to support Holland's theory of vocational choice (1973) proposing that individuals tend to choose actual occupational environments consistent with their personality types, and on the aspect of career change postulating that 'people leave because of excessive person-environment incongruent, or because of an opportunity to increase their congruity" (Holland & Gottfredson, 1976, p.21) within the limitations of this study. In the area of personality change, the results offer support for the postulate that the student body of a particular program (engineering, in this study) would have a personality pattern more consistent with the members (engineers, in this study) of the intended Occupational Environment as the length of time spent in the program increases. It also lends support to the proposition that "engineers should not be lumped together into a single category" (Dunnette et al., 1964, p.492). Vocational Preference Inventory profiles of the clients provide useful information to vocational counselors in helping engineering students in program planning and engineers in better vocational choice.

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APPENDIX A

THE UNIVERSITY OF ALBERTA

Department of Educational Psychology

PROJECT ON CAREER DEVELOPMENT

General Instructions

This is a comparative study on the vocational behavior between students in engineering programs and engineers in the field. We greatly appreciate your contribution to this project.

Please complete the questionnaire and the Vocational Preference Inventory as instructed. It will take you approximately 30 minutes to complete the task.

THANK YOU FOR YOUR CO-OPERATION AND CONTRIBUTION.

APPENDIX B

QUESTIONNAIRE X

Please complete the following by either checking the appropriate box or filling in the line:

1. Sex: Female ☐ Male ☐
2. Age: 16-18 ☐ 19-22 ☐ 23-30 ☐
   31-40 ☐ 41 or over ☐
3. Status: Citizen ☐ Permanent resident (immigrant) ☐
4. Department: Chemical Engineering ☐ Civil Engineering ☐
   Mechanical Engineering ☐ Other _____
5. Post: Junior Eng. ☐ P. Eng. ☐ Senior Eng. ☐
   Chief Eng. ☐ Other _____
6. Nature of Job duties* Basic Research ☐ Applied Research & Development ☐
   Production & Process ☐ Sales & Technical Service ☐
7. Salary: $ _____ per month
8. How long have you been in this engineering field?
   Less than a year ☐ 1 year ☐ 2 years ☐
   3-5 years ☐ 6-10 years ☐ over 10 years ☐
9. Do you like your present occupation? Please put an "X" on this scale.

   _____ _____ _____ _____ _____ _____ _____
   very much not at all
10. Have you considered changing your occupation?
    Yes ☐ No ☐
11. If yes, please indicate it here:
    I want to be a _____.
12. Please indicate how confident or confused you were on this scale with an 'X' when you made your choice in engineering program at university.

    _____ _____ _____ _____ _____ _____ _____
    very clear & confident very vague & confused

*Basic Research: Investigating problems of a fundamental nature and developing and testing hypotheses.
Applied Research & Development: Developing working models & completing experimental and pilot projects.
Production & Process: Planning efficient use of equipment and materials, simplifying production methods, and controlling expenses.
Sales & Technical Service: Working with customers' representatives, selling ideas to people, and keeping informed about competitive products and activities.

APPENDIX C

QUESTIONNAIRE Y

Please complete the following by either checking the appropriate box or filling in the line:

1. Sex: Female ☐ Male ☐

2. Age: 16-18 ☐ 19-22 ☐ 23-30 ☐
   31-40 ☐ 41 or over ☐

3. Status: Citizen ☐ Permanent resident (immigrant) ☐
   Foreign Student ☐

4. Department: Chemical Engineering ☐
   Civil Engineering ☐
   Mechanical Engineering ☐
   Other _____

5. Class level: 1st yr. ☐ 2nd yr. ☐
   3rd yr. ☐ 4th yr. ☐

6. Do you like your present program? Please put an 'X' on this scale.

   _____ _____ _____ _____ _____ _____ _____
   very much not at all

7. Have you considered changing your program?
   Yes ☐ No ☐

8. If yes, please indicate another program here:
   I want to be in _____.

9. Please indicate how confident/clear or vague/confused you were on this scale with an 'X' when you made your choice in engineering program at university.

   _____ _____ _____ _____ _____ _____ _____
   very clear and confident very vague and confused

10. Approximate Grade Point Average for all University courses:

    _____